FIG. 3

CUSTOMER 330A

CUSTOMER 330B

CUSTOMERS 330C

TRAIN STATION 340

FULFILLMENT CENTER 320

LOCKER STORAGE 360

AIRPORT 350
1200

START

1210
RECEIVE ORDER FOR ITEM FROM CUSTOMER

1220
DETERMINE ORIGIN OF ORDERED ITEM

1230
DETERMINE DESTINATION FOR ORDERED ITEM

1240
DEFINE A PLAN FOR TRANSPORTING ORDERED ITEM IN ONE OR MORE CARRIERS FROM ORIGIN TO DESTINATION WITHIN NETWORK DELIVERY SYSTEM

1250
CAUSE ORDERED ITEM TO BE PLACED WITHIN CARRIER AT ORIGIN

1260
PROVIDE INSTRUCTIONS TO MOVER SYSTEMS AND/OR DIVERSION SYSTEMS FOR AUTOMATICALLY TRANSPORTING CARRIER FROM ORIGIN TO DESTINATION VIA NETWORK DELIVERY SYSTEM

1270
CAUSE ORDERED ITEM TO BE REMOVED FROM CARRIER AT DESTINATION

STOP

FIG. 12
RECEIVE ORDER FOR ITEM FROM CUSTOMER

IDENTIFY FULFILLMENT CENTER IN POSSESSION OF ITEM

DETERMINE LOCATIONS OF FULFILLMENT CENTER AND CUSTOMER

IDENTIFY PATHS WITHIN NETWORKED DELIVERY SYSTEM BETWEEN FULFILLMENT CENTER AND CUSTOMER

DETERMINE TIME OF DELIVERY ALONG EACH OF THE PATHS

SORT PATHS BASED ON TIME OF DELIVERY

SELECT OPTIMAL PATH FOR DELIVERY OF ITEM FROM FULFILLMENT CENTER TO CUSTOMER

TRANSMIT INSTRUCTIONS TO DELIVER ITEM FROM FULFILLMENT CENTER TO CUSTOMER ALONG OPTIMAL PATH

STOP

FIG. 13
FIG. 14B
PATHS FROM FULFILLMENT CENTER 1420 TO CUSTOMER 1430C

PATH A
1420 1470 1472 1476 1430C
30 MIN

PATH A
1420 1470 1472 1476 1430C
38 MIN

PATH C
1420 1470 1476 1430C
25 MIN

PATH D
1420 1470 1478 1430C
33 MIN

PATH E
1420 1474 1478 1430C
31 MIN

MINUTES

FIG. 14C
DEDICATED NETWORK DELIVERY SYSTEMS

BACKGROUND

Today, various numbers and types of open, diverse transportation networks allow for travel between origins and destinations on one or more roadways or railroads, or air or sea routes, in a nearly limitless number of vehicles. Such networks are versatile enough to permit passengers or cargo to travel independently or together in one or more carriers, and are not typically limited to any particular function or format. For example, at any given time, an interstate highway may accommodate cars carrying one or more people, buses carrying several passengers and their belongings, delivery trucks hauling a variety of packages or parcels, police cars or fire trucks operated by one or more public authorities, and any other type of vehicle to travel thereon, at various speeds. Similarly, a rail network allows both passenger trains and freight trains to travel on a point-to-point basis on the same sets of rails. Ferries, cruise ships, container ships and tankers coexist on open bodies of water such as rivers, bays or oceans, and passenger planes, cargo aircraft (both manned and unmanned), fighter jets and helicopters frequently traverse the skies.

Each of these open transportation networks may be subjected to delays of various forms, types or causes, which may ultimately hinder or halt the passage of some or all travel thereon. For example, a traffic jam on a secondary road will slow or stop not only passenger cars but also school buses, delivery vans or ambulances intending to pass thereby. Similarly, a train derailment or maintenance issue on a critical track between two hubs or stations of a rail network will cause any trains traveling thereon to be similarly backed up, regardless of whether such trains carry passengers or cargo. Stormy seas or a lack of available slips or moorings may prevent sailboats, fishing boats and cargo ships from pulling into a port, just as hurricanes or tornadoes may ground any type of aircraft.

Moreover, in order to travel from an origin to a destination, a passenger or an object such as a container having one or more items therein must typically travel within multiple transportation networks and along multiple modes of transit. For example, a passenger intending to fly from one city to another may be required to walk to a taxi cab, ride in the taxi cab to a train station, take a train to an airport before flying to another airport, where he or she must complete a similar process in reverse prior to reaching the other city. Similarly, a parcel delivered from a warehouse or like facility is occasionally delivered by hand to a car or a truck, then to an airport, a seaport or a train station via the van or truck, and to a corresponding airport, seaport or train station, from which the item is typically delivered to a customer by another car or truck. While passengers or cargo are in transit within any of these open transportation networks or traveling by any manner, such passengers or cargo may potentially restrict or otherwise cause a delay to any other passengers or cargo traveling within such networks or by any such manner, regardless of whether such passengers or such cargo are traveling to a common destination or according to a common purpose or function.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial diagram illustrating a delivery of an item from a fulfillment center to a node associated with a customer by way of a dedicated network delivery system in accordance with the present disclosure.

FIG. 2 is a pictorial diagram illustrating components for delivering an item from a fulfillment center to multiple nodes by way of a dedicated network delivery system in accordance with the present disclosure.

FIG. 3 is a pictorial diagram illustrating components for delivering items of items to multiple nodes by way of a dedicated network delivery system in accordance with the present disclosure.

FIG. 4 is a pictorial diagram illustrating components for transporting items between nodes of a dedicated network delivery system in accordance with the present disclosure.

FIG. 5 is a pictorial diagram illustrating components for transferring items between conveyors of a dedicated network delivery system in accordance with the present disclosure.

FIGS. 6A and 6B are pictorial diagrams illustrating portions of a dedicated network delivery system for carrying items in accordance with the present disclosure.

FIG. 7 is a pictorial diagram illustrating components for transferring items from a first conveyor of a dedicated network delivery system at a first elevation to a second conveyor of the dedicated network delivery system at a second elevation in accordance with the present disclosure.

FIG. 8 is a pictorial diagram illustrating components for transferring items from a first conveyor of a dedicated network delivery system at a first elevation to a second conveyor of the dedicated network delivery system at a second elevation in accordance with the present disclosure.

FIG. 9 is a pictorial diagram illustrating conveying systems for transporting items between nodes of a dedicated network delivery system and diversion systems for transferring items between conveying systems of the dedicated network delivery system in accordance with the present disclosure.

FIG. 10 is a pictorial diagram illustrating conveying systems for transporting items between nodes of a dedicated network delivery system and diversion systems for transferring items between conveying systems of the dedicated network delivery system in accordance with the present disclosure.

FIG. 11 is a block diagram of components of a dedicated network delivery system for transporting items from a fulfillment center to a customer in accordance with the present disclosure.

FIG. 12 is a flow diagram of an illustrative process for controlling the transportation of an ordered item from an origin to a destination using a dedicated network delivery system in accordance with the present disclosure.

FIG. 13 is a flow diagram of an illustrative process for selecting a path for a delivery of an ordered item from a fulfillment center to a customer and controlling the delivery of the ordered item using a dedicated network delivery system in accordance with the present disclosure.

FIG. 14A is a pictorial diagram of a dedicated network delivery system having a plurality of paths extending between a plurality of nodes of a dedicated network delivery system in accordance with the present disclosure.

FIGS. 14B and 14C are schematic diagrams depicting illustrative optimal delivery paths determined within the dedicated network delivery system shown in FIG. 14A.

DETAILED DESCRIPTION

As is set forth in greater detail below, the present disclosure is directed to providing a dedicated, automated network
delivery system, and/or delivering an object by way of a dedicated, automated network delivery system. Such systems may be provided for the delivery of physical objects for a single purpose, or for multiple purposes, and may operate independently and discretely from traditional delivery systems, in whole or in part. In accordance with the present disclosure, a dedicated network delivery system may include both subterranean and aboveground components, including powered mover systems, such conveyors, or powered carriers (e.g., rail cars), operating on stationary network components (e.g., rails), as well as diversion systems of various types for transferring physical objects between one or more powered mover systems or powered carriers. Such components may cause the distribution of one or more objects from a central source to one of a number of distributed destinations, or between any number of nodes of a distributed system.

Additionally, the dedicated network delivery system may further include one or more control systems for automatically controlling the individual or collective operation of various powered mover systems, powered carriers or diversion systems, and thereby controlling the distribution of objects throughout the dedicated network delivery system. Such control systems may also plan one or more paths or routes for the distribution of the objects within the system, and avoid or handle any number of issues regarding system congestion that may arise in any manner.

The systems and methods of the present disclosure thus enable the delivery of items, e.g., goods of any kind or sort, in a powered and controlled manner between a source and a destination at a variety of speeds without any interaction, or with minimal interaction, with traditional transportation networks, and with minimal to no human operators. Referring to FIG. 1, a pictorial diagram is shown illustrating a delivery of an item from a fulfillment center to a node associated with a customer by way of a dedicated network delivery system 100 in accordance with the present disclosure. In the illustrated embodiment, the system 100 includes a conveyor 110 for conveying an object 10, e.g., a container storing one or more items, from a fulfillment center to one or more destinations, such as a customer 130, beneath the surface of the earth and independent of any traditional transportation system. The conveyor 110 includes a diverter 112, e.g., a pusher diverter, for transferring the object 10 from the conveyor 110 to a conveyor extension 132, which will cause the object 10 to be transported to a conveyor terminus 134 associated with the customer 130.

Therefore, using a network delivery system of the present disclosure, such as the system 100 of FIG. 1, objects may be automatically distributed from one station or location to another within the system 100, while avoiding any delays, bottlenecks, hindrances or constraints ordinarily associated with traditional transportation systems. The components of the system 100, such as the conveyor 110, the diverter 112, the extension 132 and the terminus 134 may be automatically controlled by one or more computer control systems, which may transmit any number of instructions or commands for causing the object 10 to be delivered from a fulfillment system to a customer 130 along a predetermined path between and among such components without having to rely on automobiles to travel on one or more roads, trains to pass from station to station, ships to sail on the open seas or airplanes to fly from one terminal to another, or any other type or form of carrier with an onboard human operator.

Today’s transportation networks include a variety of multimodal transportation systems, including various land, sea and air transit systems. Throughout American history, many such systems were implemented in phases over time. For example, in the first half of the nineteenth century, several thousand miles of canals such as the Erie Canal, which connected New York City and the Atlantic Ocean to Chicago and the Midwest by way of the Hudson River and the Great Lakes, were dug between various bodies of water, thereby expanding the capacity of water-based vessels to deliver goods and services to more inland destinations and between seaports. The second half of the nineteenth century was dominated by the growth of railroads and rail travel, as rail lines carrying locomotives and rail cars snaked across the continent in the wake of the Industrial Revolution, highlighted by the hammering of the Golden Spike at Promontory, Utah, which completed the first transcontinental railroad between the east and west coasts of the United States.

In the twentieth century, Henry Ford’s assembly lines began operating in 1913, thereby enabling the low cost, mass production of cars and trucks for personal use. Automobiles continued to grow in popularity and efficiency with the advent of the Eisenhower Interstate Highway System in 1956, which permitted Americans to autonomously traverse the nation at elevated speeds on wide, structurally sound roadways and bridges. Finally, with the development of wide-body airliners such as the Boeing 747 in 1969, and the deregulation of airlines in the United States beginning in 1976, the delivery of passengers and cargo by air became increasingly efficient and cost-effective in the latter half of the twentieth century.

Despite the fundamental differences between these various modes of transport, however, each of the modes suffers from similar problems in terms of reliability and efficiency. For example, while automobiles such as cars or trucks are sufficiently versatile to drive on various types of roadways including expressways, streets or driveways, the speed by which a car or a truck may travel is limited by the capacity of such roadways, as well as any associated regulatory restrictions (e.g., speed limits) or traffic operating thereon. Similarly, while some trains in the United States may travel at maximum speeds of up to 165 miles per hour, such trains are rarely, if ever, able to reach such speeds due to the shared use of many rail lines among various types of passenger and freight trains, one or more geographic constraints (e.g., limited turn radii or elevation changes) or the obligation to stop at one or more stations. Like automobiles, ships are also versatile and may travel on waterways of varying widths or depths, including bodies of water as narrow as rivers or channels, and as vast as oceans or seas. However, ships may also be limited by adverse sea, air and weather conditions, and although two-thirds of the planet is covered by water, one-third is not so covered, thereby precluding ships from reaching many land-locked destinations. Air travel is largely unfettered, in that planes may travel quickly along a shortest route to an intended destination and may avoid traffic in three dimensions, but must begin and end their journeys on dedicated airfields, which may not conveniently be located near each and every origin or destination. While each such mode of transport may permit both passengers and cargo to travel thereon, transportation on all modes may be slowed or halted by incidents of varying degrees. To a certain extent, a transportation network that is clogged by one participant, e.g., a traffic accident on a roadway, a train derailment or delayed departures or arrivals at an airport plagued by severe weather, is frequently clogged to all participants.

The systems and methods of the present disclosure are directed to dedicated, automated network delivery systems for transporting objects from one station or location to
another by way of any number of conveying systems or other mover systems. Such network delivery systems may be dedicated to a single purpose, e.g., the delivery of objects from a single source to one or more destinations, such as items delivered from a fulfillment center, a warehouse or a like facility to one or more customers. Alternatively, such network delivery systems may be directed to multiple purposes, such as the delivery of items from multiple vendors, manufacturers or merchants to a fulfillment center, and the delivery of items from the fulfillment center to multiple customers or other destinations. Additionally, the network delivery systems may include corresponding nodes or extensions associated with such fulfillment centers and customers, as well as connections with traditional transportation systems.

Some network delivery systems of the present disclosure may comprise one or more hubs, as well as any number of junctions or nodes associated with various locations or stations of the systems that are connected to each of the hubs, as well as interconnections between at least some of the hubs. Such nodes may be configured to permit travel in a single direction (e.g., to or from the node), or in multiple directions (e.g., both to and from the node), while a network delivery system of the present disclosure may include some nodes that are configured to permit travel in one direction and other nodes that are configured to permit travel in two or more directions. Some other systems of the present disclosure may comprise a single loop connecting a plurality of locations or stations to one another, while some other systems of the present disclosure may comprise two or more concentric loops connecting such locations or stations to one another. Moreover, the network delivery systems disclosed herein may comprise a single, homogenous form of mover system, such as a subterranean network of conveyor belts or rail cars traveling in a variety of directions and at a variety of elevations between any number of points or nodes, or a heterogeneous network of diverse, integrated mover systems, such as a network including conveyor belts and rail cars of any size or type operating both below and above ground.

The network delivery systems of the present disclosure may further include any number of computerized control systems for controlling the operation of the various mover systems and/or one or more diversion systems for transferring objects between such mover systems. Such control systems may be provided in a standalone location or facility dedicated to the operation of the various components of the network delivery system, or in conjunction with another location or facility, such as a fulfillment center or other location associated with the distribution of items ordered from an electronic marketplace. For example, upon identifying an origin of an object and a destination for the object, a path for transporting the object along any number of segments of one or more mover systems may be defined, and the delivery of the object along the path by way of a network delivery system may be automatically controlled from a central location or computer-based processing system, or from one or more distributed computer-based processing systems, where desired.

Where one or more of the dedicated network delivery systems of the present disclosure include multiple available paths through a variety of points or nodes between a source and a destination, e.g., between a fulfillment center and a customer, the systems and methods of the present disclosure may determine an optimal path for transporting an object from the source to the destination according to one or more algorithms, formulas or processes. The optimal path may be defined based on a shortest time or lowest cost required to transport an object from the source to the destination, or on any other factor or combination of factors, and may consider specific two-dimensional or three-dimensional locations of the various points or nodes within a dedicated network delivery system, as well as the architecture or capacities of the components or elements of the system. Information regarding an optimal path may be stored in at least one data store, and provided in the form of one or more commands or instructions to a carrier for transporting the object along the optimal path from the source to the destination.

In accordance with the present disclosure, an optimal path, or a “shortest path,” may be defined by one or more known algorithms, formulas or processes, including those previously associated with transportation between points, vertices or nodes. For example, the systems and methods of the present disclosure may define such optimal paths using one or more iterations of common mathematical principles for solving shortest path problems, including but not limited to Dijkstra’s Algorithm, the Bellman-Ford Algorithm, the Floyd-Warshall Algorithm, Johnson’s Algorithm or hub labeling.

Such algorithms, formulas or processes may also use any amount of geospatial information regarding locations of points or nodes within a distributed network delivery system, or information regarding congestion or capacity at junctions associated with such points or nodes, when identifying an optimal path for traveling between two or more of the points or nodes. For example, information regarding the locations of points or nodes may be expressed in a two-dimensional Cartesian format, or \((x_i, y_i)\) for each point or node \(i\), having a latitude \(x_i\) and longitude \(y_i\); or in a three-dimensional format, or \((x_i, y_i, z_i)\) for each point or node \(i\), referencing not only the latitude \(x_i\) and the longitude \(y_i\) of the point or node, but also an elevation or depth \(z_i\) (e.g., a subterranean or aboveground position) within the network delivery system. Such location information may be maintained or stored in one or more computer systems, and, upon receiving a request to deliver an object from one point or node to another point or node within the network delivery system, identified and accessed in connection with the request.

Additionally, where an optimal path is to be determined based on congestion at one or more points or nodes, the optimal path may be defined based on actually observed congestion at junctions associated with such points or nodes (e.g., actual carrier flow through such points or nodes) or predicted congestion at such points or nodes (e.g., estimates of carrier flow based on received orders or outstanding instructions to deliver that have been issued). Such actual or predicted congestion may be referenced in a qualitative manner (e.g., that a point or node is congested or is not congested at any given time) or in a quantitative manner (e.g., an extent to which the point or node is congested, as expressed in a percent or other numerical form). The optimal path may elect to avoid congested points or nodes, or points or nodes that are congested to a predetermined manner in accordance with the present disclosure.

The physical layout or configuration of a network delivery system may be represented as a network for the purpose of identifying an optimal path between two or more points or nodes. According to some embodiments, the network delivery system may be represented as a directed graph of varying degrees of completion. For example, a network delivery system of the present disclosure may be defined as a directed acyclic graph without any directed cycles, e.g., in which each of the edges of the graph is directed such that no path
beginning at an origin and returning to the origin may be defined based on such edges. The various paths between two or more points or nodes may be identified and topologically sorted in order to determine which of such paths is optimal, e.g., the most efficient path for traveling between such points or nodes in terms of time or cost, or according to any other metric or standard. According to some other embodiments, the network delivery system may be represented as a complete directed graph, in which each of the points or nodes is connected to one another, thereby enabling a comprehensive analysis of all available interconnections between such points or nodes when identifying the optimal path. In still other embodiments, the network delivery system may be represented as a partially completed directed acyclic graph.

As is discussed above, the network delivery systems of the present disclosure may have any number of points or nodes, and algorithms, formulas or processes for determining paths or avoiding congestion may consider each of the points or nodes in the network when defining an optimal path for the transportation of an object. Alternatively, in an effort to conserve computer processing power or to enhance the efficiency of the process of identifying an optimal path, the systems and methods disclosed herein may group one or more of the points or nodes into clusters, and then define an optimal path according to a two-element process.

First, an optimal path between and among such clusters may be defined, and, second, an optimal path within a cluster associated with a destination may be defined. For example, where a network delivery system comprises one thousand (or \(10^3\)) points or nodes, determining an optimal path between any two of such points or nodes may require up to one million (or \(10^6\), or \(10^2\) squared) steps. Where the points or nodes of the network delivery system are grouped into one hundred (or \(10^2\)) clusters of ten nodes each, determining the optimal path between any two of such points or nodes may require up to ten thousand (\(10^4\), or \(10^2\) squared) steps to determine the optimal path between clusters corresponding to each of the two points or nodes, and up to one hundred (\(10^2\), or 10 squared) steps to determine the optimal path within the destination node. Thus, the maximum theoretical number of steps required in order to define an optimal path may be reduced from 1,000,000 to 10,000, or by nearly a factor of ten.

Moreover, the transportation of objects within the network delivery systems of the present disclosure may be controlled from a control system provided at a central location, which may be associated with one or more of the hubs or nodes (e.g., a fulfillment center, a delivery destination, junction, etc.). Alternatively, the transportation of objects within such systems may be centrally controlled between groups or clusters of points or nodes, and locally controlled within such groups or clusters of points or nodes. For example, when an order for one or more items is received from a customer of an electronic marketplace and assigned to a particular a fulfillment center, the transportation of the ordered items from the fulfillment center to a destination specified by the customer may be controlled from a first (e.g., centrally located) control system as the ordered items are transported to a vicinity of the destination, where control of the transportation of the ordered items may be transferred to a second (e.g., local) control system within the vicinity of the destination until such items have reached the customer.

When planning the delivery of objects between and among nodes of a network delivery system, the systems and methods of the present disclosure may be configured to treat each object being transported as of equal importance, or in a homogenous manner, such that no one object is prioritized over any other. Alternatively, the systems and methods disclosed herein may rank each and every object, or various categories of objects, in a heterogeneous manner, in terms of their relative priority with respect to one another for the purpose of capacity planning or congestion avoidance. An item or object may be assigned a higher priority level or a lower priority level, with respect to other items or objects that are to be transported by one or more of the network delivery systems disclosed herein, based on any number of intrinsic or extrinsic factors regarding the item or object, a source or origin of the item or parcel, or a destination or recipient of the item or object. For example, items or objects having an inherent expiration or spoiling date (e.g., fresh meats or produce, or tickets to an athletic event that is slated to occur at a given date or time) may be placed ahead of, e.g., shipped sooner than, or prior to, items or objects lacking such an expiration or spoiling date in terms of priority. Similarly, items or objects for which a sender or recipient has paid an additional surcharge or fee may be placed ahead of items or objects for which neither the sender nor the recipient paid the additional surcharge or fee in terms of priority.

Because the network delivery systems disclosed herein may operate independently of other transportation networks, the various components of such systems may be installed in association with or in parallel with components of such networks, e.g., below or above existing roadways, rail lines or utility easements, or without regard to the locations or alignments of any existing transportation network facility components. Rather, the locations and alignments of the various components of the systems disclosed herein may be selected on any basis, such as cost, convenience to users, or efficiency.

Additionally, the network delivery systems disclosed herein may be constructed or assembled according to any standard form of construction. For example, any number of tunnels, channels, pipes or beds may be built to accommodate the mover systems, extensions and/or termini for the network delivery systems using any number of excavators, boring or tunneling tools and paving or pouring machines. Additionally, power may be provided to the mover systems or carriers of the present disclosure by any manner and in any form, including but not limited to alternating current (AC) electric power, direct current (DC) electric power, solar power, geothermal power, wind power, nuclear power, fuel cells or any form of petroleum-based power, e.g., gasoline, diesel fuel, natural gas and/or propane.

Notably, because the network delivery system disclosed herein may be provided for a specific purpose, e.g., delivering objects, and need not be associated with traditional transportation networks, such systems need not maintain an environment that is suitable for the survival and safety of humans or other animals, such as an environment that includes sufficient oxygen supplies and/or sanitation services, or is maintained at an acceptable temperature. Rather, the environmental conditions within the network delivery system (e.g., the environment surrounding the mover systems and/or carriers) of the present disclosure may be selected based on the particular needs or requirements of the network delivery systems in which such movers or carriers are provided. For example, where the network delivery system is intended to transport temperature-sensitive items such as chocolates or ice cream, or heated prepared foods, temperatures within the system may be preferably maintained within a defined band in order to prevent such items from melting or cooling. Where the network delivery system...
is intended to transport items that may be maintained at nearly any temperature, however, such as clothing or hardware, little to no control over the temperature associated with the system may be required other than to provide for a suitable operational environment for the various components of the system itself.

As is discussed above, the network delivery system of the present disclosure may use one or more mover systems to transport objects, items or materials of varying sizes and shapes, and typically include any number of machines or elements for causing the motion or translation of such objects, items or materials from one location or station to another. A mover system may include machines or elements that cause or enable such motion or translation. A mover system may be driven by any form of prime mover, including belts, chains, screws, rails, tracks or rollers, and the objects, items or materials may be transported in a container or carrier, or on or within the mover itself. A mover system may further include one or more pulleys, shafts, hubs, bushings, sprockets, bearings and other elements for causing a movement. Further, a mover system may convey objects, items or materials into one or more static or dynamic apparatuses, such as a bin, a chute, a cart, a track or the like.

The mover systems disclosed herein may also incorporate one or more buffer spaces or sidings for accommodating carriers that accumulate in a vicinity of junctions associated with points or nodes. For example, where a carrier that includes a variety of containers departs from a source (e.g., a fulfillment center) and approaches a junction, and a path between the junction and an ultimate destination for the carrier is congested, the carrier may be diverted to a buffer space or a siding to permit carriers, that depart from the same source and that are intended to travel to other destinations, to pass through the junction. Once the path between the junction and the ultimate destination for the carrier has been cleared, the carrier may be restored to its route from the junction to the ultimate destination. Alternatively, such buffer spaces or sidings may enable lower priority traffic to be stored in a vicinity of a junction, and thereby allow higher priority traffic to pass through the junction.

Some embodiments of the present disclosure, such as the system 100 of FIG. 1, may utilize mover systems in the form of conveying systems, such as banded continuous-loop belts (e.g., rubber or fabric) that are placed into motion by a series of two or more pulleys, at least one of which is driven by a motor. Conveyor belts may operate at various speeds, ranging from a standard speed of approximately sixty-five feet per minute (65 fpm), or about 0.7 miles per hour (0.7 mph) to a peak speed of approximately three thousand feet per minute (3000 fpm), or about thirty-three miles per hour (33 mph). Objects, items or materials may be placed directly onto the belt, or into one or more bins or like containers that may be placed on the belt. Similarly, a chain conveyor may carry one or more pendants, which may be used to pull unit loads on pallets or other large-scale containers. Conveying systems may also include a gravity conveyor, which may consist of a series of rollers that may be used to move objects based on a difference in height, and a resulting difference in gravitational potential energy, without the use of a motor.

Additionally, a mover system may include one or more diverters or diversion systems in order change a direction of travel of one or more objects within a conveying system, or to cause such objects to travel in an intended direction toward a desired destination. For example, a diverter may be used to direct an object from one conveying apparatus (e.g., an ingress conveyor belt) to another (e.g., an egress conveyor belt), or another egress apparatus such as a bin, a chute, a cart or a truck), or to remove or otherwise extricate an object from a conveying system entirely. Some common diverters include a pusher diverter, which may physically move one or more objects traveling on a conveyor into an adjacent apparatus or container, or onto another conveyor, as well as a steered wheel diverter, which may be installed in series with a conveyor, and may include one or more wheels to permit items to roll or pass thereon. The wheels of a steered wheel diverter may be pivoted to any orientation with respect to an axis or direction of travel of the conveyor, thereby causing objects traveling on the conveyor to move in a different direction upon striking the wheels of the steered wheel diverter. Any type of diverters or diversion systems may be utilized to transfer objects from one element or segment of a network delivery system to another element or segment in accordance with the present disclosure.

In addition to conveying systems, other mover systems may be provided in accordance with the present disclosure for the purpose of delivering objects on one or more network delivery systems. For example, systems comprising rack-and-pinion arrangements, e.g., with a linear gear known as a "rack," and a rotating, substantially circular gear known as a "pinion," may be used for the purpose of translating objects on flat or graded surfaces. Furthermore, systems utilizing moving or static rails of various types, and having carriers of various kinds, may be provided. For example, many trains in a traditional "light rail" system travel at approximately sixty-five miles per hour (65 mph), while standard high-speed trains may travel at speeds of one hundred fifty to two hundred fifty miles per hour (150 to 250 mph). Magnetic levitation (or "maglev") trains may also travel at speeds of approximately three hundred fifty miles per hour (350 mph). Additionally, hyperloop systems in which capsules travel within low-pressure tubes at elevated speeds of up to 700 miles per hour that may be maintained through the use of linear induction motors and air compressors may be used for delivering objects in one or more network delivery systems of the present disclosure.

The network delivery systems disclosed herein may also comprise a water-based network in which sealed carriers having one or more items therein may travel within pipes or conduits that are substantially filled with water. Such a water-based network may enable the transportation of containers at speeds determined by currents passing within the network. Those skilled in the pertinent art will recognize that any such processes or methods for causing the transportation of objects may be incorporated into a dedicated network delivery system of the present disclosure, which may utilize one or more networks of mover systems, diversion systems or other components operating according to one or more such processes or methods.

The systems and methods of the present disclosure may comprise networks arranged in any number or type of configurations between two or more locations or stations, e.g., between a fulfillment center and one or more customers, such as elements or segments aligned on any number of axes or having components at varying elevations, including subterranean components at any depths, and aboveground components at any heights. Moreover, the networks may further include extensions associated with such destinations that may extend from one or more conveying systems to a terminus or other point associated with such locations or stations, thereby enabling items to be passed from such conveying systems to the terminus. Referring to FIG. 2, a pictorial diagram illustrating components for delivering an item from a fulfillment center to multiple nodes by way of a dedicated network delivery system 200 in accordance with
the present disclosure are shown. Except where otherwise noted, reference numerals preceded by the number "2" in FIG. 2 indicate components or features that are similar to components or features having reference numerals preceded by the number "1" shown in FIG. 1.

As is shown in FIG. 2, the system 200 includes branches 210A, 210B, 210C of a main conveyor, e.g., a belted conveying system, such as the conveyor 110 of the system 100 of FIG. 1, for transporting items 20 thereon. The branch 210B of the main conveyor includes a spiral elevator extension 222 and a terminus 224 associated with a fulfillment center 220. The portion of the branch 210B shown in FIG. 2 remains entirely underground at a constant depth. The branch 210A of the main conveyor is ramped upward from the depth of the branch 210B, to a depth of a surface of the ground in a vicinity of a customer 230, viz., a home. The branch 210C of the main conveyor also comprises a vertical elevator extension 232 and a terminus 234 associated with a plurality of customers 230, viz., an apartment building. The branch 210C remains entirely underground at the constant depth of the branch 210B. The vertical elevator extension 232 is configured to lift items 20 from the depth of the branch 210C to the customers 230.

Accordingly, as is shown in FIG. 2, the systems and methods of the present disclosure may comprise any number of transportation components for causing items to travel horizontally or vertically from one location to another, such as the various branches 210A, 210B, 210C of the main conveyor shown in FIG. 2, each of which may be automatically controlled from one or more computer-based control systems. Additionally, such systems and methods may further include components or extensions for transferring items between a main conveying system and a destination (e.g., a fulfillment center, a customer or another location). Such extensions may include paths of translation that are aligned vertically, or nearly vertically, such as the vertical elevator extension 232, as well as horizontally, or nearly horizontally, or in any direction or along any axis having a combination of horizontal and vertical components, such as the spiral elevator extension 222.

Moreover, the network delivery systems and methods disclosed herein may comprise hub-and-node configurations, e.g., with a hub at a central location and spokes extending therefrom to one or more nodes, or may define looped systems having one or more extensions associated with specific locations, e.g., the vertical elevator extension 232 or the spiral elevator extension 222 of FIG. 2, which enable objects to be transported from such looped systems to or from such locations without impeding the transportation of other objects by way of such looped systems. The extensions may thereby connect various external elements with the delivery systems and methods disclosed herein, including, for example, any storage facilities, as well as connections to components of any traditional delivery systems such as highways, train depots or airports.

Referring to FIG. 3, a pictorial diagram is shown illustrating components for delivering items to multiple nodes by way of a dedicated network delivery system 300 in accordance with the present disclosure. Except where otherwise noted, reference numerals preceded by the number "3" in FIG. 3 indicate components or features that are similar to components or features having reference numerals preceded by the number "1" or "2" in FIG. 1 or 2, respectively.

As is shown in FIG. 3, the looped main conveyor 310 further connects a plurality of locations 320, 330A, 330B, 330C, 340, 350, each comprising an extension 322, 332A, 332B, 332C, 342, 352 to the looped main conveyor 310 and a corresponding terminus 324, 334A, 334B, 334C, 344, 354. The locations 320, 330A, 330B, 330C, 340, 350 include a fulfillment center 320, customers 330A, 330B (viz., single-family dwellings), customer 330C (viz., an apartment building), a train station 340, an airport 354 and a locker storage facility 360, which may be provided as a central delivery point in a dense environment such as an urban center or college campus.

The looped main conveyor 310 may comprise any number of subterranean and/or aboveground conveying elements or segments extending between two or more locations. Additionally, the looped main conveyor 310 may comprise a single loop of elements or segments configured to operate in a common revolutionary direction (e.g., clockwise or counter-clockwise) or, alternatively, multiple loops of elements or segments that are aligned in a concentric manner and operating in opposite revolutionary directions (e.g., one clockwise loop and one counter-clockwise loop).

Moreover, the looped main conveyor 310 may be homogeneous in nature, such that each of the elements or segments included therein comprises a single mover system (e.g., each of the elements or segments is a belted conveyor having similar dimensions, capacities or operating characteristics (e.g., each of the elements or segments has a common width, height or speed). Alternatively, the looped main conveyor 310 may be a heterogeneous system, including elements or segments that are different in form (e.g., elements or segments including both a belt conveyor and a static rail-based delivery system having powered rail cars operating thereon) or function (e.g., elements or segments having different dimensions, including larger dimensions and/or higher speeds in areas of high demand, or smaller dimensions and/or slower speeds in areas of low demand). Each of the elements of the looped main conveyor 310 may be controlled independently or collectively from a centrally located or localized control system (not shown) provided in a standalone location or facility dedicated to the operation of the various components of the network delivery system, or in conjunction with another location or facility.

Similarly, the extensions 322, 332A, 332B, 332C, 342, 352 to the looped main conveyor 310 and the corresponding termini 324, 334A, 334B, 334C, 344, 354 may include one or more computer-controllable features for causing items to be transferred into, and removed from, the main conveyor 310. For example, the extensions 322, 332A, 332B, 332C, 342, 352 may operate selectively in a single direction, e.g., inbound to the main conveyor 310 or outbound from the main conveyor 310, or may include two-way operating elements that permit items to be transferred to or from the main conveyor 310 in the inbound or outbound directions simultaneously. The termini 324, 334A, 334B, 334C, 344, 354 may further include any devices or systems for receiving items from, or loading items onto, the corresponding extensions 322, 332A, 332B, 332C, 342, 352.

Accordingly, using a network delivery system, such as the system 300 of FIG. 3, objects may be transported between and among each of the locations 320, 330A, 330B, 330C, 340, 350 in an automatic and controlled manner, independent of any external or traditional transportation network or system. For example, items ordered by one or more of the customers 330A, 330B, 330C from an electronic marketplace and assigned to the fulfillment center 320 may be automatically delivered to the customers 330A, 330B, 330C by way of the fulfillment center extension 322, the looped main conveyor 310 and one or more of the customer extensions 332A, 332B, 332C. One or more control systems associated with the main conveyor 310 or the fulfillment
center 320 may transmit any number of instructions or commands to such components for causing the items to be transported thereon until such items arrive at the extensions 332A, 332B, 332C associated with the customers 330A, 330B, 330C. Upon the items' arrival, one or more diverters, diversion systems or other like means may cause such items to be transferred from the main conveyor 310 to such extensions 332A, 332B, 332C, and ultimately to the termini 334A, 334B, 334C associated with such extensions 332A, 332B, 332C. Conversely, where one or more items is to be returned to the electronic marketplace for any reason, the customers 330A, 330B, 330C may place such items upon one of the extensions 332A, 332B, 332C and transferred to the main conveyor 310 thereby. The main conveyor 310 may be controlled in a manner that causes such items to be transferred to the fulfillment center extension 322 and, ultimately, to the fulfillment center 320.

Similarly, items may be transported from the fulfillment center 320 to the locker storage facility extension 360, where such items may be placed into one or more lockers or like areas (e.g., cubbies, receptacles, bins, shelves) by automatically controlling the operation of the fulfillment center extension 322, the main conveyor 310 and the locker storage facility extension 362 from one or more control centers. Items may also be returned from the locker storage facility extension 360 to the fulfillment center 320 in a reciprocal fashion.

Additionally, those skilled in the pertinent arts would also recognize that the system 300 of FIG. 3 may be configured to receive inbound shipments from vendors, manufacturers or merchants at the fulfillment center 320 by way of the train station 340, the airport 350 or any other traditional transportation network (not shown). For example, where a vendor who is not affiliated with the system 300 intends to make his or her items (e.g., goods, products, services or information of any type or form) available to customers of the marketplace by way of the fulfillment center 320, the vendor may cause one or more containers including the items to be delivered to the train station 340 or the airport 350, where such containers may be loaded onto the train station extension 342 or the airport extension 352, and ultimately to the main conveyor 310. Such extensions 342, 352 and the main conveyor 310 may be automatically controlled to cause the inbound shipment containers to be delivered to the fulfillment center 320. Conversely, the fulfillment center 320 may make outbound shipments of items to customers who are not affiliated with the system 300, by causing one or more containers or carriers including the items of an outbound shipment to be placed onto the fulfillment center extension 322, and ultimately to the main conveyor 310. The containers or carriers automatically may be transported to the train station extension 342 or the airport extension 352, where such containers or carriers may be loaded onto one or more trains or planes, respectively, and delivered to the customers who ordered the items of the outbound shipment.

As is discussed above, the various aspects of the present disclosure may be provided in any manner between locations for which the transportation of objects is desired, including within or among existing easements or publicly owned properties that are already accommodating transportation networks or utilities, or in an independent manner defined by the demand for the delivery of items by way of such network delivery systems. Referring to FIG. 4, a pictorial diagram is shown illustrating components for transporting items between nodes of a dedicated network delivery system 400 for transporting items 40 in accordance with the present disclosure. Except where otherwise noted, reference numerals preceded by the number “4” in FIG. 4 indicate components or features that are similar to components or features having reference numerals preceded by the number “1,” “2” or “3” in FIG. 1, 2 or 3, respectively.

The system 400 of FIG. 4 includes a main conveyor 410A, along with auxiliary conveyors 410B, 410C, extending in a subterranean manner beneath a city including a fulfillment center 420, as well as a plurality of customers 430A, 430B, 430C, 430D, 430E and a vendor 460 aligned on an existing aboveground street network. The system 400 further includes diverters or diversion systems 412A, 412B, 412C for transferring items 40 from the main conveyor 410A to other conveyors 410B, 410C or subterranean extensions 422, 432A, 432B, 432C, 432D, 432E, 462 associated with the fulfillment center 420, the customers 430A, 430B, 430C, 430D, 430E or the vendor 460.

For example, as is shown in FIG. 4, a diverter 412A is aligned to transfer items from the main conveyor 410A to a fulfillment center extension 422, while a diverter 412B is aligned to transfer items from the main conveyor 410A to the auxiliary conveyor 410B and a diverter 412C is aligned to transfer items from the main conveyor 410A to the auxiliary conveyor 410C. Furthermore, as is also shown in FIG. 4, the fulfillment center 420, the customers 430A, 430B, 430C, 430D, 430E or the vendor 460 each includes an aboveground terminus 424, 434A, 434B, 434C, 434D, 434E, 464. The termini 424, 434A, 434B, 434C, 434D, 434E, 464 shown in FIG. 4 are positioned in association with the alignments of the various extensions 422, 432A, 432B, 432C, 432D, 432E, 462.

Accordingly, the system 400 of FIG. 4 is a network delivery system that is aligned to transport a plurality of items 40 underground, along a plurality of conveyors 410A, 410B, 410C, such that items 40 may be transported substantially underground beginning shortly after entering the system 400, viz., upon departing the fulfillment center 420 by way of the fulfillment center extension 422, until arriving at their respective destinations, viz., at one or more of the customers 430A, 430B, 430C, 430D, 430E or the vendor 460, where the items 40 may ascend by way of the various extensions 422, 432A, 432B, 432C, 432D, 432E, 462 and arrive at their respective termini 424, 434A, 434B, 434C, 434D, 434E, 464.

Moreover, the alignment and locations of the various features of the network delivery systems of the present disclosure (e.g., the conveying systems, extensions and/or termini) may be selected on any basis and for any reason, such as cost, convenience, efficiency or the general or specific purposes for which such systems are intended. While the routes associated with the aboveground street network may have been selected according to the various land use of the neighboring parcels, or the environmental conditions in the area, the systems and methods are not so limited. Instead, decisions on the placement and configuration of network delivery system components may be made based on the long-term financial value of and demand for such systems, subject to the resolution of any matters concerning the availability or suitability of one or more aboveground or subterranean properties, and without regard to any traditional transportation network alignments.

As is discussed above, the systems and methods disclosed herein may provide a dedicated network delivery system having mover systems aligned in a hub-and-node configuration or in one or more substantially concentric loops. The mover systems may be aligned in a unidirectional manner, such that items may travel thereon in a single direction at a time, or in a bi-directional manner, such that multiple items may travel thereon in substantially opposing directions at
once. Referring to FIG. 5, a pictorial diagram is shown illustrating components for transferring items between conveyors of a dedicated network delivery system 500 for transporting items 50 in accordance with the present disclosure. Except where otherwise noted, reference numerals preceded by the number “4” in FIG. 5 indicate components or features having reference numerals preceded by the number “1,” “2,” “3,” or “4” in FIG. 1, 2, 3, or 4, respectively.

The system 500 of FIG. 5 comprises a pair of conveying systems 510A, 510B, a pair of diverters 512A, 512B and a pair of transfer surfaces 514A, 514B. As is shown in FIG. 5, the conveying systems 510A, 510B are provided for the purpose of carrying items 50 in opposing directions.

The conveying systems 510A, 510B of FIG. 5 may be provided within the system 500 as a portion of a hub-and-spoke configuration, e.g., in parallel between a hub and a node, or between hubs or nodes. Alternatively, the conveying systems 510A, 510B may be provided within the system 500 as a portion of a concentric arrangement having two or more loops aligned in the same or different directions, such as the looped main conveyor 310 of FIG. 3. Moreover, the diverters 512A, 512B are provided for the purpose of transferring the items 50 from one of the conveying systems 510A, 510B to another of the conveying systems 510A, 510B by way of the transfer surfaces 514A, 514B. For example, where one of the items 50 is traveling on the conveying system 510B, the diverter 512A may be instructed to push the item 50 across the transfer surface 514B and onto the conveying system 510A, thereby causing the item 50 to automatically reverse course. Therefore, where a dedicated network delivery system comprises one or all of the components shown in the system 500 of FIG. 5 (or like components), an item 50 may be automatically placed into motion at a first location and caused to travel toward a second destination, only to be automatically redirected to a third destination, as needed, and in accordance with the present disclosure. Any form of diverter may be provided for transferring items between conveying systems in accordance with the present disclosure.

The mover systems utilized by network delivery systems of the present disclosure may take any form, and may be configured to accommodate objects of any size or shape. For example, the conveying systems may include belted conveyors without any hooks, notches or holding extensions thereon for securing items thereto. Alternatively, the conveying systems may include indent or shaped receptacles for securing items therein. Referring to FIGS. 6A and 6B, pictorial diagrams are shown illustrating portions of dedicated network delivery systems 600A, 600B for transporting items 60A, 60B in accordance with the present disclosure. Except where otherwise noted, reference numerals preceded by the number “6” in FIG. 6A or 6B indicate components or features that are similar to components or features having reference numerals preceded by the number “1,” “2,” “3,” “4,” “5” or “6” in FIG. 1, 2, 3, 4, 5, 6A or 6B, respectively.

As is shown in FIG. 7, the system 700 includes a pair of main conveying systems 710A, 710C configured in a transverse (viz., perpendicular) alignment with regard to one another, and at different elevations. The system 700 further includes a conveying elevator 712B having a bucketed conveyor belt 7123 extending between the main conveying systems 710A, 710C, a diverter 712A and a transfer surface 714A for transferring items from the main conveying system 710A to the conveying elevator 712B, and a transfer surface 714B for transferring items from the conveying elevator 712B to the main conveying system 710C.

As is shown in FIG. 8, the system 800 also includes a pair of main conveying systems 810A, 810C configured in a transverse (viz., perpendicular) alignment with regard to one another, and at different elevations. The system 800 further includes a spiraled conveying elevator 810B having a spiraled conveyor belt 812B extending between the main conveying systems 810A, 810C, a diverter 812A and a transfer surface 814A for transferring items from the main conveying system 810A to the spiraled conveying elevator 810B, and a transfer surface 814B for transferring items from the spiraled conveying elevator 810B to the main conveying system 810C.

Therefore, according to the present disclosure, a network delivery system may comprise mover system components
operating along any axis and at any depth or elevation, and may transport objects of any type, kind or size between and among such mover system components using diverters for changing a direction of such objects within a horizontal dimension, as well as angled or sloped mover systems, or conveying elevator systems, for changing a direction of such objects in a vertical dimension. Such diverters, conveying elevator systems or like components may be automatically controlled in order to move objects from one location to another in any direction or dimension. The network delivery systems of the present disclosure are not limited in their capacity to change a direction, an elevation or a depth of an item, and may use components in addition to the conveying elevator 710B or the spiraled conveying elevator 810B shown in FIG. 7 and FIG. 8, respectively. For example, a spiraled rail conveyor may be folded around a building or other structure in order to accommodate changes in vertical depth or elevation within a short distance. Moreover, the mover system components, diverters, conveying elevator systems or like components may be individually or collectively operated by one or more computerized control systems in order to cause an object to be transported between points or nodes within a network delivery system.

As is also discussed above, the network delivery systems of the present disclosure may comprise a single type or form of mover system, such as a belted conveyor system, a static rail system having one or more movable carriers thereon, a moving belt system, or pipes or conduits that are substantially filled with water traveling at one or more speeds. Alternatively, the network delivery systems of the present disclosure may comprise multiple mover systems working in conjunction with one another. Such mover systems may have different operational characteristics or capacities.

For example, within a network delivery system of the present disclosure, an item ordered by a customer from an electronic marketplace may be transported from a first location, e.g., a hub associated with a fulfillment center, to a second location, e.g., a node located between the fulfillment center and a customer, by way of a first mover system. At the second location, the item may be transferred from the first mover system to a second mover system, and transported to a third location, which may be associated with the customer, e.g., such as one of the termini 334A, 334C associated with a home of the customer 330A, 330B, a terminus 330C associated with an apartment building having customers 330C therein or a terminus 360 associated with a locker storage facility 360. The first mover system may operate at a first speed or have a first capacity, e.g., a high-speed maglev train or hyperloop system, that may be appropriate for delivering items at high speeds or for long distances, while the second mover system may operate at a second speed or have a second capacity, e.g., a belted conveyor system or narrow-gage rail system, that may be appropriate for delivering items at slower speeds or for shorter distances.

Furthermore, the dedicated network delivery systems may be constructed with tunnels, bridges, beds or other features that are sufficiently sized in order to accommodate the mover systems, the diversion systems and/or the carriers of the present disclosure. For example, in some applications, where a segment of a dedicated network delivery system is known or expected to experience elevated levels of traffic or demand, or to carry large items, larger mover systems (e.g., wider belted conveyors) passing through taller tunnels or along sturdier bridges may be provided. In other applications, where a segment of a dedicated network delivery system is known or expected to experience reduced levels of traffic or demand, or to carry small items, smaller mover systems (e.g., narrower belted conveyors) passing through shorter tunnels or along lighter bridges may be provided. The various aspects (e.g., mover systems, diversion systems and/or carriers) of the dedicated network delivery systems of the present disclosure may be selected on any basis, and any corresponding structures, facilities or components of any size, shape or capacity may be provided accordingly, as necessary.

Referring to FIGS. 9 and 10, pictorial diagrams illustrating conveying systems for transporting items between nodes of dedicated network delivery systems 900, 1000 and diversion systems for transferring items between such systems 900, 1000 in accordance with the present disclosure are shown. Except where otherwise noted, reference numerals preceded by the numbers “9” or “10” in FIG. 9 or 10 indicate components or features that are similar to components or features having reference numerals preceded by the number “1,” “2,” “3,” “4,” “5,” “6,” “7” or “8” in FIGS. 1, 2, 3, 4, 5, 6A and 6B, 7 or 8, respectively.

As is shown in FIG. 9, the system 900 includes a hyperloop conveying system 910A and a belted conveyor system 910B. The hyperloop conveying system 910A may be any type or form of system having a low-pressure or vacuum tube including a plurality of capsules 920A that may travel within the tube at controllable speeds between two or more locations. Such capsules may be suspended aloft within the tube on one or more cushions of air, and may be powered using one or more magnetic accelerators (e.g., linear induction motors), and may transport one or more items 90A, 90B therein. Hyperloop capsules may be transported within such tubes at speeds exceeding seven hundred miles per hour (700 mph). The belted conveyor system 910B may be any form of conveying system having one or more belts that may transport a plurality of items 90A, 90B, 90C, 90D therein. Typical belted conveyors may operate at speeds ranging from approximately sixty-five feet per minute to approximately three thousand feet per minute (65 to 3,000 fpm), or about seven-tenths of a mile per hour to about thirty-three miles per hour (0.7 to 33 mph). Additionally, the system 900 further includes a diverter 912A for transferring items from the belted conveyor system 910B to the hyperloop conveying system 910A, or vice versa, along a transfer surface 914A.

As is shown in FIG. 10, the system 1000 includes a maglev rail conveying system 1010A and a narrow-gage rail conveying system 1010B. The maglev rail conveying system 1010A may be any type or form of magnetic levitation train system including one or more carriers 1020A that may operate in a low-friction environment according to electromagnetic suspension, electrodynamic suspension or any other levitation device. Some such maglev trains may reach speeds of over three hundred miles per hour (300 mph). The narrow-gage rail conveying system 1010A may include one or more powered rail carriers 1020A for transporting items 10D, 10E therein. The narrow-gage rail conveying system 1010B may be a rail system having specially sized carrier cars, such as the carrier 1020B of FIG. 10, that are particularly adapted for the transportation of lighter items or objects, or along rails having tighter turn radii or steeper changes in elevation. The system 1000 further includes a diverter 1012A for transferring items from the maglev rail conveying system 1010A to the narrow-gage conveying system 1010B, or vice versa, along the transfer surface 1014A.

Accordingly, the network delivery systems of the present disclosure may include any number, type or form of mover
systems, including but not limited to belted conveyors or any type or form of static rail system, such as are shown in FIG. 9 or FIG. 10, and such mover systems may operate in conjunction with one another in order to accomplish the transportation of objects between two or more locations. As is discussed above, the transportation of objects within a network delivery system may be centrally controlled by the transmission of one or more instructions or commands from a control system, such that the objects traveling therefore may be delivered from one location to another outside of a traditional transportation network, and without requiring any manned intervention. More particularly, once an item has been designated for delivery, the item may enter the network delivery system, e.g., from the fulfillment center 320 by way of one or more of fulfillment center extensions 322, as is shown in FIG. 3, and be caused to travel along one or more mover systems, e.g., the main conveyor 310 of FIG. 3, before arriving at an intended destination, where the item may exit the network delivery system, e.g., by way of one or more customer extensions 332A, 332B, 332C, automatically and without any interaction by one or more human operators.

Referring to FIG. 11, a block diagram is shown of illustrative components of a dedicated network delivery system 1100 for transporting items from a fulfillment center 1120 to a customer 1130. The system 1100 comprises a marketplace 1100, the fulfillment center 1120, the customer 1130 and a delivery network 1140 that are connected to one another across a communications network 1150, such as the Internet. Although the system 1100 is shown as transporting items from the fulfillment center 1120 to the customer 1130 by way of the dedicated network 1140, the systems and methods of the present disclosure are not so limited, and may be utilized when transporting items between two or more locations for any specific purpose.

The marketplace 1110 may be any entity or individual that intends to make items from a variety of sources (e.g., vendors, manufacturers, merchants) available for download, purchase, rent, lease or borrowing by customers using a networking computer infrastructure, including one or more physical computer servers 1112 and data stores 1114 for hosting a network site 1116. The marketplace 1110 may be physically or virtually associated with one or more storage or distribution facilities, such as the fulfillment center 1120. The network site 1116 may be implemented using the one or more servers 1112, which connect or otherwise communicate with the one or more data stores 1114 as well as the network 1150, as indicated by line 1118, through the sending and receiving of digital data. Moreover, the data stores 1114 may include any type of information regarding items that have been made available for sale through the marketplace 1110, or ordered by customers from the marketplace 1110.

The fulfillment center 1120 may be any facility that is adapted to receive, store, process and/or distribute items. As is shown in FIG. 11, the fulfillment center 1120 includes a computer 1122, as well as stations for receiving, storing and distributing items to customers, including but not limited to a receiving station 1121, a storage area 1123 and a distribution station 1125.

The fulfillment center 1120 may operate one or more order processing and/or communication systems using a computing device such as the computer 1122 and/or software applications having one or more user interfaces 1124 (e.g., a browser), or through one or more other computing devices or machines that may be connected to the network 1150, as is indicated by line 1128, in order to transmit or receive information in the form of digital or analog data, or for any other purpose. The computer 1122 may also operate or provide access to one or more reporting systems for receiving or displaying information or data regarding workflow operations, and may provide one or more interfaces, such as the user interface 1124, for receiving interactions (e.g., text, numeric entries or selections) from one or more operators, users or workers in response to such information or data. The computer 1122 may be a device or machine that features any form of input and/or output peripherals such as scanners, readers, keyboards, keypads, touchscreen or like devices, and may further operate or provide access to one or more engines for analyzing the information or data regarding the workflow operations, or the interactions received from the one or more operators, users or workers.

The receiving station 1121 may include any apparatuses that may be required in order to receive shipments of items at the fulfillment center 1120 from one or more sources and/or through one or more channels, including but not limited to docks, lifts, cranes, jacks, belts or other conveying apparatuses for obtaining items and/or shipments of items from carriers such as cars, trucks, trailers, freight cars, container ships or cargo aircraft (e.g., manned aircraft or unmanned aircraft, such as drones), and preparing such items for storage or distribution to customers. The storage area 1123 may include one or more predefined two-dimensional or three-dimensional spaces for accommodating items and/or containers of such items, as aile, rows, bays, shelves, slots, bins, racks, tiers, bars, hooks, cubbies or other like storage, or any other appropriate regions or stations. The distribution station 1125 may include one or more regions or stations where items that have been retrieved from a designated storage area may be evaluated, prepared and packed for delivery from the fulfillment center 1120 to addresses, locations or destinations specified by customers, also by way of carriers such as cars, trucks, trailers, freight cars, container ships or cargo aircraft (e.g., manned aircraft or unmanned aircraft, such as drones). Those skilled in the pertinent arts will recognize that shipments of items arriving at the receiving station 1121 may be processed, and the items placed into storage within the storage areas 1123 or, alternatively, transferred directly to the distribution station 1125, or “cross-docked,” for prompt delivery to one or more customers.

The fulfillment center 1120 may further include one or more control systems (not shown in FIG. 11) that may generate instructions for conducting operations at one or more of the receiving station 1121, the storage area 1123 or the distribution station 1125. Such control systems may be associated with the computer 1122 or with one or more other computing devices or machines, and may communicate with such devices or machines by any known wired or wireless connection, or with the marketplace 1110 or the customer 1130 over the network 1150, as indicated by line 1128, through the sending and receiving of digital data.

Additionally, the fulfillment center 1120 may include one or more systems or devices (not shown in FIG. 11) for determining a location of one or more elements therein, such as cameras or other image recording devices. Furthermore, the fulfillment center 1120 may also include one or more workers or staff members, who may handle or transport items within the fulfillment center 1120. Such workers may operate one or more computing devices or machines for registering the receipt, retrieval, transportation or storage of items within the fulfillment center, such as the computer 1122, or a device such as a personal digital assistant, a digital media player, a smartphone, a tablet computer, a desktop computer or a laptop computer, and may include any form
of input and/or output peripherals such as scanners, readers, keyboards, keypads, touchscreens or like devices.

The customer 1130 may be any entity or individual that wishes to download, purchase, rent, lease, borrow or otherwise obtain items (which may include goods, products, services or information of any type or form) from the marketplace 1110. The customer 1130 may utilize one or more computing devices, such as a smartphone 1132 or any other like machine that may operate or access one or more software applications, such as a browser (not shown) or a shopping application 1134, and may be connected to or otherwise communicate with the marketplace 1110 or the fulfillment center 1130 through the network 1150, as indicated by line 1138, by the transmission and receipt of digital data. Moreover, the customer 1130 may also receive deliveries or shipments of one or items from facilities maintained by or on behalf of the marketplace 1110, such as the fulfillment center 1120, by way of the dedicated delivery network 1140.

The dedicated delivery network 1140 comprises a plurality of mover systems 1142-1, 1142-2 ... 1142-n and a plurality of m diversion systems 1144-1, 1144-2 ... 1144-m for transporting items from the fulfillment center 1120 to the customer 1130, and a control system 1146. The mover systems 1142-1, 1142-2 ... 1142-n may comprise any number of components for causing the transportation of items from one location to another, including one or more belted conveyor systems, static rail or moving rail systems, rack-and-pinion systems or the like. For example, such mover systems 1142-1, 1142-2 ... 1142-n may include stationary carriers and moving conveyors, such as is shown with regard to the belted conveyor system 910B of FIG. 9, or moving carriers and stationary rails, such as is shown with regard to the hyperloop conveying system 910A of FIG. 9. Moreover, the mover systems 1142-1, 1142-2 ... 1142-n may further include any necessary extensions and/or termini which may be required in order to transfer items into or out of the delivery network 1140, such as the conveyor extension 1132 or the conveyor terminus 1134 associated with the customer 130 of FIG. 1, at one or more locations.

The diversion systems 1144-1, 1144-2 ... 1144-m are provided for the purpose of transferring items from one of the mover systems 1142-1, 1142-2 ... 1142-n to another of the mover systems 1142-1, 1142-2 ... 1142-n. Such diversion systems 1144-1, 1144-2 ... 1144-m may also include any type of diverters or diversion systems for transferring objects from one mover system to another, and at any elevation or depth. Any type of diverters or diversion systems may be utilized to transfer objects from one element or segment of a network delivery system to another element or segment in accordance with the present disclosure.

The control system 1146 may control any aspect of the operation of the various mover systems 1142-1, 1142-2 ... 1142-n or the various diversion systems 1144-1, 1144-2 ... 1144-m, or any other systems, within the dedicated network 1140. For example, the control system 1146 may define a path between an origin and a destination, e.g., between the fulfillment center 1120 and the customer 1130, for transporting an object along one or more of the mover systems 1142-1, 1142-2 ... 1142-n, such as by selecting one or more particular mover systems 1142-1, 1142-2 ... 1142-n or diversion systems 1144-1, 1144-2 ... 1144-m for causing the delivery of the object according to any defined purpose and consistent with any particular requirements. Additionally, the control system 1146 may transmit one or more instructions or commands for controlling the operation of various components of the mover systems 1142-1, 1142-2 ... 1142-n (e.g., belts, chains, screws, rails tracks or rollers of conveyor systems, powered carriers operating on static rails or mobile rails or the like) or the diversion systems 1144-1, 1144-2 ... 1144-m, such as by causing a pusher diverter or a steered wheel diverter to move an item from one conveyor to another.

The control system 1146 may be provided as a freestanding system or facility associated with the dedicated network 1140. Alternatively, the control system 1140 may be further provided in connection with one or more other components of the system 1100 of FIG. 11, such as the marketplace 1110 or the fulfillment center 1120. For example, the control system 1146 may be provided in connection with the server 1112 or with one or more other computer-related components of the marketplace 1110, and may be integrated with one or more aspects of the processes by which orders may be received from the customer 1130 or assigned to the fulfillment center 1120. Alternatively, the control system 1146 may be provided in connection with the computer 1122 or with one or more other computer-related components of the fulfillment center 1120, and may be integrated with one or more aspects of the processes by which orders may be fulfilled on behalf of the customer 1130 from the fulfillment center 1120.

Additionally, the control system 1146 may include one or more computers, servers and/or devices featuring the necessary electronics, software, memory, storage, databases, firmware, logic/state machines, microprocessors, communication links, displays or other visual or audio user interfaces, printing devices, and any other input/output interfaces to provide any of the functions or services regarding the operation of any one of the various mover systems 1142-1, 1142-2 ... 1142-n or the various diversion systems 1144-1, 1144-2 ... 1144-m within the dedicated network 1140. Such computers, servers and/or devices may be operated independently, or may receive instructions or commands from one or more external computer devices or system components, such as the server 1112 or the computer 1122, by way of the network 1150, as indicated by line 1148, through the sending and receiving of digital data.

For example, according to the systems and methods of the present disclosure, an order for the purchase of an item may be received from the customer 1130 by the marketplace 1110 through the marketplace network site 1116. Upon acknowledging the receipt of the order, the marketplace server 1112 may provide one or more instructions for fulfilling the order to the fulfillment center 1120 over the network 1150. Such instructions may be received at the computer 1122, which may then instruct one or more workers to retrieve the item from the storage area 1123 and to prepare the item for delivery to the customer 1130 at the distribution station 1125, such as by placing the item in a suitable container with an appropriate amount and type of dunnage.

Once the item has been prepared for delivery, a path for transporting the item from the fulfillment center 1120 to the customer 1130 by way of the dedicated network 1140 may be defined by the control system 1146, which may transmit one or more instructions for causing the item to be automatically transferred from the distribution station to the dedicated network 1140 by way of one or more extensions or termini associated with the fulfillment center 1120, such as the fulfillment center extension 322 of FIG. 3. The control system 1146 may transmit further instructions for causing the item to be automatically transferred to the mover system 1142-1, or for causing the item to travel to a location associated with the customer 1130 by way of one or more of
the other mover systems 1142-2 . . . 1142-n. Upon its arrival at the location associated with the customer 1130, the control system 1146 may transmit further instructions for causing the item to be automatically transferred from one of the mover systems 1142-2 . . . 1142-n to an extension associated with the customer 1130, such as one of the extensions 332A, 332B, 332C of FIG. 3. Accordingly, an object may be automatically delivered from an origin to a destination, e.g., from a fulfillment center 1120 to a customer 1130, by way of a dedicated delivery network 1140 having any number of mover systems 1142-1, 1142-2 . . . 1142-n using any number of diversion systems 1144-1, 1144-2 . . . 1144-m, each of which may be individually or collectively operated by the control system 1146, or by one or more other computerized control systems.

The computers, servers, devices and the like described herein have the necessary electronics, software, memory, storage, databases, firmware, logic/state machines, microprocessors, communication links, displays or other visual or audio user interfaces, printing devices, and any other input/output interfaces to provide any of the functions or services described herein and/or achieve the results described herein. Also, those skilled in the pertinent arts will recognize that users of such computers, servers, devices and the like may operate a keyboard, keypad, mouse, stylus, touch screen, or other device (not shown) or method to interact with the computers, servers, devices and the like, or to “select” an item, link, node, hub or any other aspect of the present disclosure.

Those skilled in the pertinent arts will understand that process elements described herein as being performed by a “marketplace,” a “fulfillment center,” a “customer” or a “delivery network” or like terms, may be automated steps performed by their respective computer systems, or implemented within software modules (or computer programs) executed by one or more general purpose computers. Moreover, process steps described as being performed by a “marketplace,” a “fulfillment center,” a “customer” or a “delivery network” may be typically performed by a human operator, but could, alternatively, be performed by an automated agent.

The marketplace 1110, the fulfillment center 1120, the customer 1130 and/or the fulfillment center 1140 may use any network-enabled or Internet applications or features, or any other client-server applications or features including electronic mail (or E-mail), or other messaging techniques, to connect to the network 1150 or to communicate with one another, such as through short or multimedia messaging service (SMS or MMS) text messages. For example, the fulfillment center 1120 and/or the computer 1122 may be adapted to transmit information or data in the form of synchronous or asynchronous messages to the server 1112, the server 1112, the smartphone 1132, the control system 1146 or any other computer device in real time or in near-real time, or in one or more offline processes, via the network 1150. Those skilled in the pertinent arts would recognize that the marketplace 1110, the fulfillment center 1120, the customer 1130 or the dedicated network 1140 may operate any of a number of computing devices that are capable of communicating over the network, including but not limited to set-top boxes, personal digital assistants, digital media players, tablets, pads, laptop computers, desktop computers, electronic book readers, and the like. The protocols and components for providing communication between such devices are well known to those skilled in the art of computer communications and need not be described in more detail herein.
other location to which the ordered item is to be delivered may be identified from the order, e.g., a home or office location of the customer, an address of an intended recipient where the ordered item is intended as a gift, or a convenient central location selected by the customer where the item is to be picked up; and a corresponding station or extension of the network delivery system may be identified.

At box 1240, a plan for transporting the ordered item within one or more carriers from the origin to the destination is defined. For example, a control system may define the plan based on any relevant factor regarding the delivery of the item by way of the network delivery system, including but not limited to the capacity or congestion associated with one or more mover systems, or the availability of carriers of an appropriate type or capacity to transport the ordered item. Additionally, where a network delivery system includes a variety of multi-modal mover systems for transporting items, such as the hyperloop conveying system 910A or the belted conveyor system 910B of FIG. 9, or the maglev rail conveying system 1010A or the narrow-gage rail conveying system 1010B of FIG. 10, the control system may define the plan by selecting one or more of such mover systems based on the available capacity for shipping the ordered item, or the cost of transporting the ordered item by way of each such mover system. The plan may further call for transferring the ordered item in multiple segments corresponding to multiple mover systems, such that the ordered item is transported for longer, unimpeded distances by way of a high-speed mover system such as a hyperloop conveying system or maglev rail conveying system, before being transferred to a low-speed mover system such as a belt conveying system or narrow-gage rail conveying system using one or more diversion systems.

At box 1250, the ordered item is placed within a carrier at the origin. For example, one or more workers may package the ordered item into a container with an appropriate type and amount of dunnage, and load the packaged ordered item into a carrier associated with a mover system. Alternatively, the ordered item may be transferred into a carrier associated with the mover system by one or more automatic devices or systems, including one or more automated conveying systems that may be associated with a facility located at the origin, such as a fulfillment center or warehouse.

At box 1260, instructions for automatically transporting the ordered item from the origin to the destination may be provided to the one or more carriers in accordance with the plan. For example, referring again to the system 1100 of FIG. 11, the control system 1146 may provide one or more sets of instructions for transporting the ordered item by way of one or more of the mover systems 1142-1, 1142-2, ..., 1142-m and the plurality of m diversion systems 1144-1, 1144-2, ..., 1144-m, in order to cause the ordered item to travel between the origin and the destination in fulfillment of the order. At box 1270, the ordered item is removed from a carrier at the destination, and the process ends.

Accordingly, the systems and methods of the present disclosure may cause an automatic delivery of an object, such as an item ordered by a customer, from an origin to a destination in a controlled manner by way of a network delivery system, without requiring any interaction, or with minimal interaction, with traditional transportation networks or human operators. A control system can be provided information regarding an origin of the item, a destination for the item, the available facilities (e.g., mover systems or carriers, diversion systems and the like), and any utilization or congestion information associated with any aspect of the network delivery system. The delivery of the ordered item from an origin to a destination may be centrally controlled by a single control system associated with the network delivery system or, alternatively, by multiple control systems, such that control of the delivery may be transferred from a local control system to a remote control system as the ordered item travels from one geographic area to another.

As is also discussed above, the systems and methods of the present disclosure may also identify an optimal path for a delivery of an object by way of a network delivery system based on any available information regarding the operation of the network delivery system. Such information may include, but is not limited to, the times or costs required in order to transport the object along one or more paths of the network delivery system, as well as any congestion or delays along such paths, or congestion or delays at one or more points or nodes of the network delivery system. Referring to FIG. 13, a flow diagram 1300 is shown of an illustrative process for selecting a path for a delivery of an ordered item from a fulfillment center to a customer and controlling the delivery of the ordered item using a dedicated network delivery system.

At box 1310, an order is received from a customer, and at box 1320, a fulfillment center in possession of the item is identified. For example, the customer may place the order through one or more electronic systems over the Internet, by telephone or mail, or in person, and one or more fulfillment centers, warehouses or like facilities having the item onsite may be identified. At box 1330, the locations of the customer and the fulfillment center are determined. For example, information regarding the street addresses associated with the customer and the fulfillment center, may be determined and provided to a control system. Where multiple fulfillment centers are in possession of the item, a fulfillment center that is most conveniently located with regard to the customer, or from which the item may be most efficiently delivered, may be selected.

At box 1340, one or more paths extending between the fulfillment center and the customer within a network delivery system are identified. For example, where the network delivery system includes a variety of segments extending between and among various points or nodes from the fulfillment center to the customer, a control system may identify the various available paths across such segments and through such points or nodes from the fulfillment center to the customer. As is discussed above, the network delivery system may be represented as a directed graph of points or nodes joined by segments having varying degrees of completion, such as a partially or completely directed acyclic graph without any directed cycles. The various paths formed by segments between such points or nodes may be defined according to any known algorithm or processes, including but not limited to Dijkstra’s Algorithm, the Bellman-Ford Algorithm, the Floyd-Warshall Algorithm, Johnson’s Algorithm or hub labeling, and associated with the order for the item.

At box 1350, times of delivery along each of the paths identified at box 1340 are determined. For example, a control system may determine the amount of time required to deliver an object along each of a plurality of mover systems extending between various points or nodes, as well as the amount of time required to pass through junctions associated with each of the points or nodes. The determination of such times of delivery may consider any relevant information or data regarding the operational capacities of a network delivery system as a whole, or of one or more segments or junctions of the system independently. For
example, the current numbers and capacities of operational or available mover systems, diversion systems, carriers, extensions and the like may be determined for each of the paths defined at box 1340, and the amount of time required to transport the ordered item from the fulfillment center to the customer for each of such paths may be calculated by the control system. The times of delivery may be calculated with regard to any relevant information or data associated with the order, including any specific instructions or requirements for handling the ordered item, as well as any priority status assigned to the order or the ordered item, or any other factor.

At box 1360, the paths identified at box 1340 are sorted based on their respective times of delivery, as determined at box 1350. At box 1370, an optimal path for the delivery of the ordered item from the fulfillment center to the customer is selected. Alternatively, according to some other embodiments of the present disclosure, the optimal path may be defined based on any other relevant factor, including an optimal manner of delivery, a lower cost or any other qualitative or quantitative measure associated with the delivery of items.

At box 1380, instructions for delivering the ordered item from the fulfillment center to the customer are provided, and the process ends. For example, a control system may provide such instructions to one or more human operators, or to one or more computer-based machines or control systems associated with mover systems, diversion systems or any other components of a network delivery system for causing the ordered item to be transported from the fulfillment center to the customer by way of one or more such mover systems.

Such instructions may automatically cause a belted conveying system to transport an item from one point or node to another point or node, or, alternatively, may be provided to a human operator of a hyperloop conveying system or maglev rail conveying system carrying the ordered item (e.g., on a computer display or in another format) for the purpose of causing the ordered item to be delivered between such points or nodes. Moreover, such instructions may automatically cause one or more diversion systems to transfer the ordered item from one mover system to another, or to an extension associated with a destination defined by the customer. The instructions may define any number of operational characteristics regarding the operation of such systems, including a time of departure or arrival for the ordered item, a speed at which the ordered item should travel on a mover system, or a time at which a diversion system may be triggered to transfer the ordered item from one mover system to another mover system.

Accordingly, the systems and methods of the present disclosure may be configured to identify a plurality of paths for transporting an object, such as an item ordered from an electronic marketplace, from an origin to a destination along a network delivery system. An optimal path may be determined based on any factor, including but not limited to a time or cost of delivery. Instructions for transporting the object from the origin to the destination by way of the network delivery system may be provided by way of a control system to one or more mover systems and/or diversion systems.

The process of determining an optimal path for transporting an item from an origin to a destination by way of an optimal path in accordance with the present disclosure may be shown with regard to FIG. 14A. Referring to FIG. 14A, components of one dedicated network delivery system 1400A in accordance with the present disclosure are shown. Except where otherwise noted, reference numerals preceded by the number “14” in FIG. 14A, FIG. 14B or FIG. 14C indicate components or features that are similar to components or features having reference numerals preceded by the number “3” in FIG. 3.

As is shown in FIG. 14A, the system 1400A includes a main conveyor 1410 extending between locations corresponding to a fulfillment center 1420, customers 1430A, 1430B, 1430C, a train station 1440, an airport 1450 and a locker storage facility 1460. As is shown in FIG. 14, the main conveyor 1410 further includes paths extending between intersection points 1470, 1472, 1474, 1476, 1478. As is discussed above, the systems and methods of the present disclosure may be used to identify an object to be transported from an origin to a destination via a network delivery system, to determine an optimal path for transporting the object from the origin to the destination through the network delivery system, and to transport the object by way of the optimal path. As is further discussed above, the network delivery system may be represented as a network having one or more segments, and a number of paths extending between the origin and the destination across such segments may be identified. The optimal path may be defined by a control system based on an analysis of the costs or constraints associated with travel along each of the corresponding segments of each of the paths extending between the origin and the destination, and instructions for transporting the object from the origin to the destination along the optimal path may be provided to various mover systems, diversion systems or other related components of the network delivery system.

Referring to FIG. 14B, a schematic diagram 1400B depicting illustrative optimal delivery paths determined within the system 1400A shown in FIG. 14A is shown. The diagram 1400B includes a plurality of points 1420, 1430A, 1430B, 1430C, 1440, 1450, 1460, 1470, 1472, 1474, 1476, 1478 corresponding to the fulfillment center 1420, the customers 1430A, 1430B, 1430C, the train station 1440, the airport 1450 and the locker storage facility 1460 shown in FIG. 14A. The network 1410 is shown as a partially directed acyclic graph, with some of the segments (e.g., the segment between point 1470 and point 1476) indicating available travel in two directions, and some of the segments (e.g., the segment between point 1474 and point 1470) indicating available travel in a single direction.

The network 1410 also indicates travel times and directions between each of the points 1420, 1430A, 1430B, 1430C, 1440, 1450, 1460, 1470, 1472, 1474, 1476, 1478 in the network 1410. For example, as is shown in FIG. 14B, travel in the network 1410 between the point 1474 and the adjacent point 1470 would take ten minutes, while travel between the point 1474 and the adjacent point 1478 would take sixteen minutes. Such travel times may be calculated using one or more computer processors based on any available information regarding congestion, delays or capacities along such paths or associated with such points or nodes.

Thus, by representing the various features of a network delivery system in the form of a network having segments extending between two or more points or nodes, a variety of paths extending between an origin and a destination through such points or nodes may be determined. In particular, paths between two non-adjacent points may be defined by aligning two or more segments in series. For example, where an object (e.g., an ordered item) is to be transported from the fulfillment center 1420 to the customer 1430C, as is shown in FIG. 14A, five paths may be defined as extending between the point 1420 and the point 1430C in the network 1410 of FIG. 14B, and a travel time on any such path defined
between the point 1420 and the point 1430C in the network 1410 may be defined as a sum of the travel times along each of the segments.

A first path (e.g., Path A) begins at the point 1420 associated with the fulfillment center and extends through the point 1472 and the point 1476 before reaching the point 1430C associated with the customer. A second path (e.g., Path B) begins at the point 1420 and extends through the point 1474, the point 1470, the point 1472 and the point 1476 before reaching the point 1430C. A third path (e.g., Path C) begins at the point 1420 and extends through the point 1474, the point 1470 and the point 1476 before reaching the point 1430C. A fourth path (e.g., Path D) begins at the point 1420 and extends through the point 1474, the point 1470 and the point 1478 before reaching the point 1430C. Finally, a fifth path (e.g., Path E) begins at the point 1420 and extends through the point 1474 and the point 1478 before reaching the point 1430C.

According to the systems and methods of the present disclosure, an optimal path for the delivery of an object from an origin to a destination may be determined on the basis of time, cost or on any other relevant factor regarding the delivery. The optimal path may be determined by topologically sorting information regarding each of the available paths (e.g., times, costs or delivery along such paths) and selecting one of the paths based on the topologically sorted information. Referring to FIG. 14C, a schematic diagram 1400C depicting information regarding illustrative optimal delivery paths determined within the system 1400A shown in FIG. 14A is shown. The diagram 1400C includes timelines associated with the paths extending between the fulfillment center 1420 and the customer 1430C within the system 1400A of FIG. 14A.

The diagram 1400C indicates the aggregate travel time along each of the five paths extending between the fulfillment center 1420 and the customer 1430C of FIG. 14A, as represented in the network 1410 of FIG. 14B. For example, a travel time of thirty (30) minutes is defined for Path A by adding the times associated with travel between point 1420 and point 1472 (viz., twelve minutes), between point 1472 and point 1476 (viz., fifteen minutes), and between point 1476 and point 1430C (viz., three minutes). Similarly, as is shown in FIG. 14C, travel times of thirty-eight (38) minutes, twenty-five (25) minutes, thirty-three (33) minutes and thirty-one (31) minutes are defined for Path B, Path C, Path D and Path E, respectively. Although the travel times shown for Path A, Path B, Path C, Path D and Path E of FIG. 14C are defined by aggregating the travel times of the segments of such paths as shown in the network 1410 of FIG. 14B, such travel times may further include any additional factor taking into account congestion at each of the points or nodes within such paths, any traditionally observed error or variances in the estimated travel times shown in FIG. 14B, or any other relevant factors.

Once the travel times of each of the paths extending between the fulfillment center 1420 and the customer 1430C of FIG. 14A are determined, a control system may select an optimal path for the delivery of an object from the fulfillment center 1420 to the customer 1430C based on such travel times or on any other intrinsic or extrinsic information. Accordingly, as is shown in FIG. 14C, the shortest travel time between the fulfillment center 1420 and the customer 1430C is associated with Path C, which may be determined to be the optimal path for the delivery of an object from the fulfillment center 1420 to the customer 1430C on this basis. Once an optimal path is identified, the control system may provide instructions for transporting the object from the fulfillment center 1420 to the customer 1430C to one or more mover systems or diversion systems associated with the dedicated network delivery system 1400A of FIG. 14A, and the object may be automatically delivered along Path C accordingly.

Although the disclosure has been described herein using exemplary techniques, components, and/or processes for implementing the systems and methods of the present disclosure, it should be understood by those skilled in the art that other techniques, components, and/or processes or other combinations and sequences of the techniques, components, and/or processes described herein may be used or performed that achieve the same function(s) and/or result(s) described herein and which are included within the scope of the present disclosure. For example, although some of the embodiments described herein or shown in the accompanying figures refer to the use of belted conveying systems, the systems and methods disclosed herein are not so limited, and may be utilized along with any type of mover system, including but not limited to belted conveying systems or other forms of conveying systems, as well as static rail or moving rail systems of any kind, rail-and-pinion systems, hyperloop systems or water-based networks in which sealed carriers having one or more items therein may travel within pipes or conduits that are substantially filled with water.

Those skilled in the pertinent arts will recognize that the systems and methods disclosed herein are not limited to a single form of mover system, e.g., a belted conveyor system, or the various combinations of mover systems disclosed herein, e.g., the combined multi-modal dedicated network delivery systems shown in FIGS. 9 and 10. Rather, any form of mover system may be provided in accordance with the present disclosure for the purpose of transporting one or more objects within one of the dedicated network delivery systems disclosed herein. Moreover, those skilled in the pertinent arts will also recognize that the objects transported by the dedicated network delivery systems of the present disclosure may include items of any shape or kind that may, but need not be, provided in one or more containers. Furthermore, although some of the systems or methods disclosed herein are directed to the identification of optimal paths for the delivery of an object from a first point to a second point based on factors such as time of delivery or cost of delivery, the systems and methods disclosed herein are not so limited, and an optimal path may be identified on any basis, including any of the qualitative or quantitative factors disclosed herein, or on any other relevant factors associated with the delivery of the object.

Although some of the embodiments described herein describe specific systems or methods for transporting objects, or for controlling or changing the velocity of such objects in transit, the systems and methods of the present disclosure are not so limited, and may be used with any process or method for conveying any form or type of object. Additionally, such process or methods may be used in series or in parallel, and independently or in conjunction with one another, in accordance with the present disclosure.

It should be understood that, unless otherwise explicitly or implicitly indicated herein, any of the features, characteristics, alternatives or modifications described regarding a particular embodiment herein may also be applied, used, or incorporated with any other embodiment described herein, and that the drawings and detailed description of the present disclosure are intended to cover all modifications, equivalents and alternatives to the various embodiments as defined by the appended claims. Moreover, with respect to the one or more methods or processes of the present disclosure...
described herein, including but not limited to the flow charts shown in FIG. 12 or 13, the orders in which such methods or processes are presented are not intended to be construed as any limitation on the claimed inventions, and any number of the method or process steps or boxes described herein can be combined in any order and/or in parallel to implement the methods or processes described herein. Also, the drawings herein are not drawn to scale, particularly regarding the relative locations of aspects or elements of the network delivery systems disclosed herein to one another in vertical and/or horizontal space.

Conditional language, such as, among others, “can,” “could,” “might,” or “may,” unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey in a permissive manner that certain embodiments could include, or have the potential to include, but do not mandate or require, certain features, elements and/or steps. In a similar manner, terms such as “include,” “including,” and “includes” are generally intended to mean “including, but not limited to.” Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment.

The elements of a method, process, or algorithm described in connection with the embodiments disclosed herein can be embodied directly in hardware, in a software module stored in one or more memory devices and executed by one or more processors, or in a combination of the two. A software module can reside in RAM, flash memory, ROM, EPROM, EEPROM, registers, a hard disk, a removable disk, a CD-ROM, a DVD-ROM or any other form of non-transitory computer-readable storage medium, media, or physical computer storage known in the art. An example storage medium can be coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium can be integral to the processor. The storage medium can be volatile or nonvolatile. The processor and the storage medium can reside in an ASIC. The ASIC can reside in a user terminal. In the alternative, the processor and the storage medium can reside as discrete components in a user terminal.

Disjunctive language such as the phrase “at least one of X, Y, or Z,” or “at least one of X, Y, and Z,” unless specifically stated otherwise, is otherwise understood with the context as used in general to present that an item, term, etc., may be either X, Y, or Z, or any combination thereof (e.g., X, Y, and/or Z). Thus, such disjunctive language is not generally intended to, and should not, imply that certain embodiments require at least one of X, at least one of Y, or at least one of Z to each be present.

Unless otherwise explicitly stated, articles such as “a” or “an” should generally be interpreted to include one or more described items. Accordingly, phrases such as “a device configured to” are intended to include one or more recited devices. Such one or more recited devices can also be collectively configured to carry out the stated recitations. For example, “a processor configured to carry out recitations A, B and C” can include a first processor configured to carry out recitation A working in conjunction with a second processor configured to carry out recitations B and C.

Language of degree used herein, such as the terms “about,” “approximately,” “generally,” “nearly” or “substantially” as used herein, represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms “about,” “approximately,” “generally,” “nearly” or “substantially” may refer to an amount that is within less than 10% of, within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01% of the stated amount. As another example, in certain embodiments, the terms “nearly vertical” or “nearly horizontal” may refer to a value, amount, or characteristic that departs from exactly vertical or exactly horizontal by not more than 15º, 10º, 5º, 3º, 1º, 0.1º or otherwise.

Although the invention has been described and illustrated with respect to illustrative embodiments thereof, the foregoing and various other additions and omissions may be made therein and thereto without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. A system comprising: a hub associated with a fulfillment center, at least one node associated with a customer; a plurality of subterranean conveyors configured to transport at least one item, wherein a first conveyor extends along a first axis at least in part between the hub and a first junction, wherein a second conveyor extends along a second axis at least in part between the first junction and the at least one node; a first diverter at the first junction, wherein the first diverter is aligned to transfer items from a surface of the first conveyor to a surface of the second conveyor or from the surface of the second conveyor to a surface of the first conveyor; and a control system comprising at least one computer device, the control system configured to at least: receive information regarding an order for the at least one item from the customer over a communications network; determine that the at least one item is available at the fulfillment center; and upon determining that the at least one item is available at the fulfillment center, cause the at least one item to be placed onto the surface of the first conveyor at the hub; cause the at least one item to be transported from the hub to the first junction via at least the first conveyor; cause the at least one item to be transferred from the surface of the first conveyor to the surface of the second conveyor by the first diverter at the first junction; and cause the at least one item to be transported from the first junction to the at least one node via at least the second conveyor.

2. The system of claim 1, wherein the control system is further configured to at least: identify information regarding a plurality of paths extending between the hub and the at least one node; select an optimal path of the plurality of paths for transporting the at least one item from the hub to the at least one node based at least in part on the information, wherein the optimal path includes the first conveyor, the first junction and the second conveyor; and cause the at least one item to be transported from the hub to the at least one node by way of the first conveyor, the first junction and the second conveyor along the optimal path.
3. The system of claim 2, wherein the information regarding the plurality of paths comprises at least one of: predicted travel times associated with each of the paths; or predicted travel costs associated with each of the paths.

4. The system of claim 1, wherein at least a portion of the first conveyor is provided at a first vertical elevation, wherein the second conveyor is provided at a second vertical elevation, wherein the first diverter comprises a conveying elevator provided between the first conveyor and the second conveyor, and wherein the conveying elevator is configured to transfer the at least one item from the first conveyor at the first vertical elevation to the second conveyor at the second vertical elevation.

5. A system comprising:

- at least one powered mover system comprising a plurality of segments and at least one diversion system, wherein at least one of the plurality of segments extends between a first station and a second station, wherein the at least one diversion system is configured to transfer objects between at least two of the plurality of segments, and wherein the at least one of the plurality of segments is subterranean; and
- a control system comprising at least one computer device, the control system in communication with the at least one powered mover system, wherein the at least one powered mover system is configured to transport an object from the first station to the second station on the at least one of the plurality of segments, and wherein the control system is configured to at least:
  - receive information regarding a request for the object from a customer over a network;
  - select an origin of the object based at least in part on the request, wherein the first station is associated with the origin;
  - identify a destination for the object designated by the customer based at least in part on the request, wherein the second station is associated with the destination;
  - cause the object to be placed onto a surface of a first segment at the first station; and
  - provide at least one instruction to the at least one powered mover system, wherein the at least one instruction causes the at least one powered mover system to at least:
    - transport the object from the first station to at least one junction on the surface of the first segment;
    - transfer, by the at least one diversion system, the object from the surface of the first segment to a surface of a second segment; and
    - transport the object from the at least one junction on the second segment to the second station on the surface of the second segment.

6. The system of claim 5, wherein the first segment comprises a conveyor system having at least one conveyor belt, and wherein the object is caused to be placed onto a surface of the at least one conveyor belt at the first station; and

wherein the object is transported from the first station to the at least one junction on the surface of the at least one conveyor belt.

7. The system of claim 6, wherein the second segment comprises a rail system having at least one powered rail car, wherein the object is transferred from the surface of the at least one conveyor belt to a surface of the at least one powered rail car at the at least one junction by the at least one diversion system, and wherein the object is transported from the at least one junction to the second station on the surface of the at least one powered rail car.

8. The system of claim 5, further comprising:

- at least one extension associated with the second station, wherein the at least one instruction further causes the at least one powered mover system to at least:
  - transfer, by the at least one diversion system, the object from the surface of the second segment to the at least one extension.

9. The system of claim 5, wherein the at least one of the plurality of segments is configured to transport the object in at least two directions.

10. The system of claim 5, wherein the plurality of segments define at least one loop extending between the first station and the second station.

11. The system of claim 10, wherein the plurality of segments define two concentric loops extending between the first station and the second station.

12. The system of claim 5, wherein the at least one diversion system comprises a conveying elevator configured to transfer the object from the surface of the first segment at a first depth to the surface of the second segment at a second depth.

13. The system of claim 5, wherein the first station is associated with a fulfillment center, and wherein the second station is associated with one of a single-family dwelling, an apartment building, an office building, a locker storage facility, a rail station or an airport.

14. The system of claim 5, wherein the first station is associated with a merchant, and wherein the second station is associated with a customer.

15. The system of claim 5, wherein the control system is further configured to at least:

- identify a plurality of origins of the object, wherein each of the origins is associated with a fulfillment center having access to the object, and wherein the selected origin of the object is one of the plurality of origins for the object; and
- predict, for each of the plurality of origins, a level of traffic congestion between each of the plurality of origins and the destination for the object designated by the customer,

wherein the selected origin of the object is selected based on a lowest level of traffic congestion between the selected origin and the destination for the object designated by the customer.

16. The system of claim 6, wherein the at least one conveyor belt comprises a holding extension thereon.

* * * *
Described is an airborne fulfillment center ("AFC") and the use of unmanned aerial vehicles ("UAV") to deliver items from the AFC to users. For example, the AFC may be an airship that remains at a high altitude (e.g., 45,000 feet) and UAVs with ordered items may be deployed from the AFC to deliver ordered items to user designated delivery locations. As the UAVs descend, they can navigate horizontally toward a user specified delivery location using little to no power, other than to stabilize the UAV and/or guide the direction of descent. Shuttles (smaller airships) may be used to replenish the AFC with inventory, UAVs, supplies, fuel, etc. Likewise, the shuttles may be utilized to transport workers to and from the AFC.
PROCESSOR(S) 122
MEMORY 124
INVENTORY MANAGEMENT SYSTEM 126

REMOTE COMPUTING RESOURCE(S) 110

FIG. 1
ORDER DELIVERY SELECTION PROCESS

RECEIVE ORDER FOR ITEM

DETERMINE ESTIMATED DELIVERY TIMEFRAME

DELIVERY LOCATION WITHIN DELIVERY RANGE?

YES

AFC SELECTED BY USER FOR DELIVERY?

YES

DESIGNATE AFC FOR DELIVERY OF ITEM

NO

DESIGNATE OTHER DELIVERY OPTION FOR DELIVERY OF ITEM

FIG. 8
UAV ITEM DELIVERY PROCESS 900

ENGAGE ITEM 902

DEPLOY UAV FROM AFC AND NAVIGATE USING LITTLE TO NO POWER TOWARD DELIVERY LOCATION 904

ENTERED UAV NETWORK? 906

ENGAGE PROPELLERS AND NAVIGATE TO DELIVERY LOCATION 909

ARRIVE AT DELIVERY LOCATION AND DISENGAGE ITEM 910

SEND CONFIRMATION OF DELIVERY OF ITEM 912

NAVIGATE TO SHUTTLE FOR TRIP TO AN AFC? 914

RETURN TO OTHER DESIGNATED LOCATION 918

FOLLOW RETURN PATH TO SHUTTLE 916

FIG. 9
AFC ADVERTISING AND DELIVERY PROCESS

NAVIGATE AFC TO ADVERTISING ALTITUDE

PRESENT ADVERTISING FROM AFC

ORDER RECEIVED FOR ADVERTISED ITEM?

UAV ITEM DELIVERY PROCESS 900 (FIG. 9)

UPDATE ADVERTISING INFORMATION

CONTINUE ADVERTISEMENT?

NAVIGATE AFC FROM ADVERTISING ALTITUDE

COMPLETE

FIG. 10
SHUTTLE PROCESS 1100

LOAD INBOUND ITEMS (E.G., INVENTORY, UAVS, SUPPLIES, FUEL, WORKERS) INTO SHUTTLE 1102

DEPART FOR AFC? 1104

YES

NAVIGATE TO AFC 1105

DOCK WITH AFC 1106

UNLOAD INBOUND ITEMS FROM SHUTTLE TO AFC 1108

OUTBOUND ITEMS (E.G., OVERSTOCK, WORKERS, WASTE)? 1110

NO

YES

LOAD OUTBOUND ITEMS FROM AFC ONTO SHUTTLE 1112

UNDOCK AND NAVIGATE TO NEXT DESTINATION 1114

FIG. 11
FIG. 12
FIG. 13

DATA STORE 1309

MEMORY 1312

OPERATING SYSTEM 1314

BIOS 1316

DATA STORE MANAGER 1321

INVENTORY MANAGEMENT SYSTEM 1326

PROCESSOR 1300

VIDEO DISPLAY ADAPTER 1302

DISK DRIVE 1304

INPUT/OUTPUT INTERFACE 1306

NETWORK INTERFACE 1308

TO DISPLAY

TO INPUT/OUTPUT DEVICES

TO NETWORK DEVICES

SERVER SYSTEM 1320
AIRBORNE FULFILLMENT CENTER UTILIZING UNMANNED AERIAL VEHICLES FOR ITEM DELIVERY

BACKGROUND

Many companies package items and/or groups of items together for a variety of purposes, such as e-commerce and mail-order companies that package items (e.g., books, CDs, apparel, food, etc.) to be shipped to fulfill orders from users. Retailers, wholesalers, and other product distributors (which may collectively be referred to as distributors) typically maintain an inventory of various items that may be ordered by users. A ground-based building, such as a materials handling facility, may maintain and process and ship such inventory.

Typically ordered items are packed in shipping packages (e.g., corrugated boxes) and shipped to the user’s residence or place of business. Physical delivery of items to user specified locations has improved dramatically over the years, with some retailers offering next day delivery of ordered items. The final or last mile delivery of physical items to a user specified location is traditionally accomplished using a human controlled truck, bicycle, cart, etc. For example, a user may order an item for delivery to their home. The item may be picked from a ground-based materials handling facility, packed and shipped to the user for final delivery by a shipping carrier. The shipping carrier will load the item onto a truck that is driven by a human to the final delivery location and the human driver, or another human companion with the driver, will retrieve the item from the truck and complete the delivery to the destination. For example, the human may hand the item to a recipient, place the item on the user’s porch, store the item in a post office box, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical components or features.

FIG. 1 is a block diagram of a delivery environment that includes an airborne fulfillment center, according to an implementation.

FIG. 2 is a diagram of an unmanned aerial vehicle network, according to an implementation.

FIG. 3 is a diagram illustrating an unmanned aerial vehicle delivery process that utilizes an airborne fulfillment center, according to an implementation.

FIG. 4 is an illustration of an airborne fulfillment center and a shuttle docked with the airborne fulfillment center, according to an implementation.

FIG. 5 is an illustration of a shuttle, according to an implementation.

FIG. 6 is an illustration of a top-down view of an unmanned aerial vehicle, according to an implementation.

FIG. 7 is another illustration of an unmanned aerial vehicle, according to an implementation.

FIG. 8 is a flow diagram of an example order delivery selection process, according to an implementation.

FIG. 9 is a flow diagram of an example unmanned aerial vehicle item delivery process, according to an implementation.

FIG. 10 is a flow diagram of an example airborne fulfillment center advertising and delivery process, according to an implementation.

FIG. 11 is a flow diagram of an example shuttle process, according to an implementation.

FIG. 12 is a block diagram of an example unmanned aerial vehicle control system, according to an implementation.

FIG. 13 is a block diagram of an illustrative implementation of a server system that may be used with various implementations.

While implementations are described herein by way of example, those skilled in the art will recognize that the implementations are not limited to the examples or drawings described. It should be understood that the drawings and detailed description thereto are not intended to limit implementations to the particular form disclosed but, on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope as defined by the appended claims. As used throughout this application, the word “may” is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense (i.e., meaning must). Similarly, the words “include,” “including,” and “includes” mean including, but not limited to. Additionally, as used herein, the term “coupled” may refer to two or more components connected together, whether that connection is permanent (e.g., welded) or temporary (e.g., bolted), direct or indirect (i.e., through an intermediary), mechanical, chemical, optical, or electrical. Furthermore, as used herein, “horizontal” flight refers to flight traveling in a direction substantially parallel to the ground (i.e., sea level), and that “vertical” flight refers to flight traveling substantially radially outward from the earth’s center. It should be understood by those having ordinary skill that trajectories may include components of both “horizontal” and “vertical” flight vectors.

DETAILED DESCRIPTION

This disclosure describes systems and methods for utilizing an aerial fulfillment center (“AFC”) and unmanned aerial vehicles (“UAV”) to facilitate delivery of ordered items to users. An AFC may be a fulfillment center that is supported by and/or incorporated into an airship. An airship, or dirigible, is a type of aerostat or lighter-than-air aircraft which can navigate through the air under its own power. Airships gain their lift from gas that is less dense than the surrounding air, such as helium or hot air.

An AFC may be positioned at an altitude above a metropolitan area and be designed to maintain an inventory of items that may be purchased by a user and delivered to the user by a UAV that is deployed from the AFC. For example, a user may browse an e-commerce website and place an order for an item that is in the inventory of the AFC. Upon placing the order for the item, fulfillment instructions may be sent to the AFC and a UAV within the AFC may engage the item for delivery to the user. When the UAV departs the AFC, it may descend from the high altitude of the AFC using little or no power other than to guide the UAV towards its delivery destination and/or to stabilize the UAV as it descends.

When the UAV approaches earth, the UAV may engage the motors of the UAV and utilize the lifting forces generated by the motors and corresponding propellers of the UAV to slow the descent of the UAV and to complete navigation to the user specified delivery location. When the UAV reaches the delivery location, it may disengage the ordered item and complete the delivery.

After completing an item delivery, the UAV may navigate to a nearby ground-based materials handling facility or a shuttle replenishment location. Because of the high altitude of the AFC, navigation by a UAV back to the AFC may not be feasible, or an efficient use of power. Accordingly, a replen-
ishment shuttle may be provided at a shuttle replenishment location that is configured to transport inbound items (e.g., UAVs, inventory, workers, supplies, fuel) to the AFC and retrieve outbound items (e.g., overstock inventory, transshipments, workers, waste) from the AFC. For example, the replenishment shuttle may be another, smaller, airship that is used to transport items to and from the AFC.

By utilizing an AFC for the storage and delivery of items using UAVs, the power required to complete an item delivery is substantially reduced. Rather than the UAV having to operate at power from the time it departs the materials handling facility to the delivery location and back to the materials handling facility (or another location), the UAV may be deployed from the AFC and descend under the forces of gravity toward a delivery location using little to no power. Only as the UAV approaches earth does it need to fully engage the UAV motors to maintain flight and complete delivery of the item.

The use of an AFC and shuttles also provides another benefit in that the AFC can remain airborne for extended periods of time. In addition, because the AFC is airborne, it is not limited to a fixed location like a traditional ground based materials handling facility. In contrast, it can navigate to different areas depending on a variety of factors, such as weather, expected demand, and/or actual demand.

An AFC may navigate to an area based on various positioning factors. For example, a temporal event (e.g., a football game) may be expected to produce a demand for certain types of items (e.g., sporting paraphernalia, food products, etc.). In advance of the event, the items may be delivered to the AFC in a quantity sufficient to satisfy the expected demand and the AFC may navigate to a position such that UAVs deployed from the AFC can safely navigate to the location of the event and deliver the items, thereby satisfying the demand. In some implementations, the AFC may navigate to a lower altitude and provide advertising for the temporal event or for other occasions (e.g., product announcements, product releases, sales).

As still another benefit, items may be delivered within minutes of a user placing an order. For example, a user may place an order for delivery of item A, which is maintained in the inventory of an AFC within a defined distance from the user. Item A may be picked from inventory, engaged by a UAV and the UAV may be deployed from the AFC. The picking of item A through deployment may be completed within minutes of the user’s order. In some implementations, some UAVs may be pre-engaged with inventory items so that when an order for such an item is received, a UAV with the engaged inventory can be immediately deployed, further reducing the delivery time.

Deployed UAVs may quickly descend toward a user specified delivery location (e.g., the location of the user) and deliver the item. This speed of delivery provides near instant gratification to users for item purchases and greatly increases the breadth of items that can be delivered. For example, perishable items or even prepared meals can be delivered in a timely fashion to a user. In general, any item that can be carried by a UAV may be delivered using the implementations discussed herein.

An inventory management system may be configured to communicate (e.g., wirelessly) with the AFC, shuttle(s), and/or UAV(s). In various implementations, the general activities of the AFC, shuttles(s) and/or UAVs (e.g., related to the delivery of items, the replenishment of inventory and/or UAVs to the AFC, the travel of UAVs to and from the designated delivery locations, etc.) may be coordinated by the inventory management system. For example, the inventory management system may receive or determine schedule data for the travel of the shuttles to and from the AFC. In various implementations, the inventory management system may also receive tracking data (e.g., GPS) regarding the locations of the AFCs, shuttles and/or UAVs and use that data for various purposes (e.g., status monitoring, answering location status requests, sending notifications regarding the current location of the AFCs, shuttles, UAVs).

FIG. 1 is a block diagram of a delivery environment 100 that includes an AFC 102, according to an implementation. As will be described in more detail below, an AFC 102 may be utilized to store inventory items and facilitate UAV delivery of ordered items to users.

The delivery environment 100 includes a user interface 104 that allows a user 104 to place an order for an item that is to be delivered to the user. The user interface may be a graphical user interface, an audio only interface, a multi-mode interface, or any other interface for interacting with the user 104. The user interface may be provided to the user 104 through any type of electronic device 106, such as a tablet, desktop, laptop, smart phone, personal digital assistant, netbook, etc. The user interface may be delivered to the electronic device 106 by one or more remote computing resources 110 that make up part or all of an electronic-commerce shopping environment. In other implementations, the user interface may provide a direct communication between a user and an agent.

The remote computing resources 110 may form a portion of a network-accessible computing platform implemented as a computing infrastructure of processors, storage, software, data access, and other components that is maintained and accessible via a network. Services, such as e-commerce shopping services, offered by the remote computing resources 110 do not require that the user have knowledge of the physical location and configuration of the system that delivers the services. The electronic device 106 may communicatively couple to the remote computing resources 110 via the network which may represent wired technologies (e.g., wires, USB, fiber optic cable, etc.), wireless technologies (e.g., RF, cellular, satellite, Bluetooth, etc.), and/or other connection technologies. The network carries data between the electronic device 106 and the remote computing resources 110.

After receiving from a user 104 an order for an item that may be transported by a UAV 112 from an AFC 102 and delivered to a user specified delivery location, the electronic device 106 may send this information to the remote computing resources 110 over the network. As illustrated, the remote computing resources 110 may include one or more servers, such as servers 120(1), 120(2), . . . , 120(N). These servers 120(1)-(N) may be arranged in any number of ways, such as server farms, stacks, and the like that are commonly used in data centers. Furthermore, the servers 120(1)-(N) may include one or more processors 122 and memory 124 that may store an inventory management system 126.

The inventory management system 126 may be configured, for example, to perform order planning and filling of materials handling facility 130, to perform order planning, replenishment for AFCs 102 and/or to perform order planning and fulfillment of orders by UAVs 112 and/or by traditional delivery mechanism (e.g., vehicles). In various implementations, one or more AFCs 102 may be configured to generally perform some or all of the functions that are traditionally done by a ground-based materials handling facility 130, except they are airborne.

A shuttle 150 may be used to replenish the AFC 102. For example, as UAVs 112 are deployed from an AFC 102 to deliver ordered items to a user 104, the AFC is depleted of
both inventory and UAVs. The inventory management system 212 may instruct UAVs, after completing a delivery, to navigate to a shuttle positioned at a replenishment area. The shuttles 150 may be loaded with UAVs, inventory, workers, materials handling equipment, and/or other inbound items and navigate to the AFC 102 to replenish the AFC 102. Likewise, a shuttle, after offloading the inbound items at the AFC 102, may receive outbound items (e.g., overstocked items, transshipment items, workers, materials handling equipment, waste) from the AFC 102 and transport those items back to a ground based materials handling facility 130 and/or to another location.

The AFC 102, UAVs 112 and/or the shuttles 150 may communicatively couple to the remote computing resources 110 via a network. For example, the communications to and from the AFC 102, shuttles 150 and/or UAVs 112 may utilize wireless antennas of the AFC 102, shuttles 150 and/or UAVs 112.

In various implementations, the inventory management system 126 and/or AFC 102 may send instructions to or otherwise control the UAVs 112 for delivering items, navigating to shuttles, navigating to materials handling facilities 130, and the like. As discussed further below with respect to FIGS. 2-3, UAVs 112 that are operating at lower altitudes may form a UAV network 200, alone or in combination with the inventory management system 126. Landed shuttles 150 and/or ground based materials handling facilities 130. In some implementations, the UAV network 200 may also include the AFC 102, airborne shuttles 150 and/or UAVs descending from higher altitudes.

In various implementations, the remote computing resources 110 and/or inventory management system 126 may also receive tracking data (e.g., GPS) regarding the coordinates of the UAVs 112, shuttles 150 and/or AFCs 102. The GPS data may be utilized for various purposes, such as answering location status requests or for sending notifications regarding the current locations of the AFCs and/or UAVs. For example, a user may request that a notification be sent when an UAV 112 with an item ordered by the user has departed the AFC and/or is approaching. As another example, a notification may be sent to a UAV that has completed an item delivery identifying a location of a shuttle 150 to which the UAV 112 is to navigate. Notifications may also be sent from the AFC 102, shuttles 150 and/or UAVs 112 to the remote computing resources 110 and/or inventory management system 126 regarding various events (e.g., when a UAV 112 has been deployed from an AFC, when a shuttle has reached capacity, when an AFC is running low on inventory and/or UAVs).

FIG. 2 depicts a block diagram of a UAV network 200 that includes UAVs 212, delivery locations 251, materials handling facilities 230 and an inventory management system 226, according to an implementation.

Each of the UAVs 212, delivery locations 251, shuttle replenishment locations 251, materials handling facilities 230 and/or inventory management system 226 may be configured to communicate with one another. For example, the UAVs 212 may be configured to form a wireless network 200 that utilizes Wi-Fi or another wireless means of communication, each UAV communicating with other UAVs within a wireless range. In different implementations, the UAVs 212, inventory management system 226, materials handling facilities 230, shuttle replenishment locations 251 and/or the delivery locations 251 may utilize existing wireless networks (e.g., cellular, Wi-Fi, satellite) to facilitate communication. In some implementations, one or more of the inventory management system 226, materials handling facilities 230, delivery locations 251 and/or shuttle replenishment locations 251 may also communicate with each other via another network (wired and/or wireless), such as the Internet. Likewise, a shuttle (not shown) and/or an AFC (not shown) may communicate with and/or be part of the wireless network 200.

As discussed above, the inventory management system 226 may be configured to communicate with the delivery locations 251, UAVs 212, materials handling facilities 230, AFCs, shuttles, and/or shuttle replenishment locations 251. As an example, position information for each UAV 212 may be determined and shared among UAVs. Each UAV may periodically transmit, for example, ADS-B information to other UAVs in the network. When information, such as ADS-B information, is sent to or from a UAV, the information may include an identifier for the UAV and each UAV may act as a node within the network, forwarding the information until it is received by the intended UAV. For example, the inventory management system 226 may send a message to UAV 212-6 by transmitting the information and the identifier of the intended receiving UAV to one or more of UAVs 212-1, 212-2, 212-3 that are in wireless communication with the inventory management system 226. Each receiving UAV will process the identifier to determine if it is the intended recipient and then forward the information to one or more other UAVs that are in communication with the UAV. For example, UAV 212-2 may forward the message and the identification of the intended receiving UAV to UAV 212-1, 212-3 and 212-5. In such an example, because UAVs 212-1, 212-3 have already received and forwarded the message, it may discard the message without forwarding it again, thereby reducing load on the network 200. The other UAVs, upon receiving the message, may determine that they are not the intended recipient and forward it on to other nodes. This process may continue until the message reaches the intended recipient.

In some implementations, if a UAV loses communication with other UAVs via the wireless network 200, it may activate another wireless communication path to regain connection. For example, if a UAV 212 cannot communicate with any other UAVs via the network 200, it may activate a cellular and/or satellite communication path to obtain communication information from the inventory management system 226, materials handling facility 230, shuttle replenishment location 251 and/or a delivery location 253. If the UAV still cannot regain communication and/or if it does not include an alternative communication component, it may automatically and autonomously navigate toward a designated location (e.g., a nearby materials handling facility 230, shuttle replenishment location 251 and/or delivery location 253).

The wireless mesh network 200 may be used to provide communication between UAVs (e.g., to share weather information including wind speeds and directions, location information, routing information, landing areas), the inventory management system 226, materials handling facilities 230, delivery locations 251 and/or shuttle replenishment locations 251.

In addition, in some implementations, the wireless network 200 may be used to deliver content and/or other information to other computing resources, such as personal computers, electronic book reading devices, audio players, mobile telephones, tablets, desktops, laptops, etc. For example, the mesh network may be used to deliver electronic book content to electronic book reading devices of users.

FIG. 3 is a block diagram illustrating an unmanned aerial vehicle delivery process that utilizes an airborne fulfillment center 202, according to an implementation. As illustrated, an AFC 202 may be positioned above a metropolitan area 304 at a high altitude (referred to herein as a fulfillment center alti-

FIGS. 2-3, 102-212-3, 226, 102-45, 126, 130.
tude). For example, the AFC 302 may be positioned at an altitude of 45,000 feet or more above the metropolitan area 304. Positioning the AFCs 302 at an altitude above 45,000 feet, which is approximately 42,000 feet. Because the AFCs 302 are not in the flight path of other aerial vehicles, they can remain at a position for extended periods of time without disrupting other aerial systems. Likewise, by placing the AFC 302 at a fulfillment center altitude, the area that can be serviced by UAVs 312 deployed from the AFC 302 to deliver items is increased. For example, UAVs deployed from the AFC 302 may travel horizontally as they descend, thereby expanding the coverage area of the AFC 302.

In some implementations, the AFCs 312 may include a wing or other airfoil, as illustrated in FIG. 7, thereby further extending their ability to travel horizontally during descent without requiring much or any power consumption. As orders are placed by users in the metropolitan area 304 for items that are included in the inventory of the AFC 302, the item is engaged by a UAV 312 and the UAV 312 is deployed from the AFC 302. As the UAV 312 descends, it may navigate toward the user specified delivery location using wings and/or propellers of the UAV 312. For example, if the UAV 312 includes a wing, it may glide down from the AFC 302 and navigate toward the delivery location using the ailerons of the wing to control the direction of the descent. Likewise, the propellers of the UAV may be allowed to freely rotate from the forces of wind passing over the propellers during the descent. The rotation of the propellers may act as generators to provide any additional charging needed for the power modules of the UAV 312.

As the UAV 312 enters the UAV network 300, the UAV 312 communicates with other UAVs 312. Likewise, the UAV 312 may engage the motors and corresponding propellers to slow the descent of the UAV 312 and complete the navigation of the UAV 312 to the user specified delivery location within the metropolitan area 304 and deliver the item.

Upon completion of item delivery, the UAV 312 may navigate to a shuttle replenishment location 351 that includes a shuttle 350, to a materials handling facility 330, which may also include a shuttle replenishment location, and/or to another location. UAVs 312 deployed from an AFC 302 may be instructed to return to the AFC 302 via a shuttle or may be incorporated into the UAV network 300 to deliver items from a materials handling facility or other location. Likewise, UAVs 312 that are part of the UAV network 300 may be instructed to load onto a shuttle 350 and be provided to the AFC 302 for deployment.

As illustrated, one or more shuttles 350 may be used to replenish the AFC 302, thereby extending the duration of flight of the AFC 302. For example, shuttles 350 may deliver inbound items, discussed below, to the AFC 302. Like the AFCs 302, the shuttles 350 may be airships and may ascend from earth and navigate to and dock with the AFC 302 without consuming large amounts of power. The shuttles 350 may be smaller than the AFC 302 and configured to make multiple trips to and from the AFC 302 providing inbound items to the AFC and retrieving outbound items from the AFC 302.

In some implementations, multiple AFCs 302 may be positioned at altitudes to provide coverage for a larger area. Shuttles within the larger area may provide inbound items to any of the AFCs 302, retrieve outbound items from the AFCs 302 and/or navigate between the AFCs 302. Accordingly, some shuttles 350 may be used to provide inbound items and/or retrieve outbound items from multiple AFCs 302 and/or to provide items between AFCs. In some implementations, shuttles may navigate between AFCs, transshipping items, without returning to earth. In such an implementations, the shuttle 350 may receive fuel and/or service while docked at one of the AFCs 302.

In operation, when an order for one or more items is placed by a user, the order is assigned for fulfillment. The inventory management system may determine if there is an AFC 302 within a delivery range of the user specified delivery location for the order and whether that AFC includes the ordered items. If an AFC is within range and has the inventory, the order may be associated with the AFC for delivery. If the inventory is not available at an AFC within range of the delivery location, the item may be transported to an AFC for delivery or delivered directly from a ground-based materials handling facility.

In some implementations, the AFC 302 may navigate to a lower altitude (e.g., 2,000 feet above the metropolitan area 304) to provide advertising, decrease the delivery time and/or to satisfy an expected demand (e.g., at a temporal event). For example, the exterior of the AFC 302 may include one or more output devices (e.g., visual, audible) that can be used to present advertising or other information about items and/or services. For example, if 100 units of Item A are offered for sale for delivery from the AFC 302, the AFC 302 may navigate to a lower altitude (referred to herein as an advertising altitude) and present an advertisement regarding the sale and the number of units remaining. A user may place an order for the item (Item A), the item is picked from inventory, and deployed for delivery. In some implementations, to further increase the speed at which items are delivered as part of a sale, the quantity offered for sale may be pre-engaged by UAVs and as soon as the item is ordered, a UAV with the item may be deployed for delivery.
FIG. 4 is an illustration of an AFC 402 and a shuttle 450 docked with the AFC 402, according to an implementation. As illustrated, the AFC 402 may be configured as an airship. An airship is a type of aerostat or lighter-than-air aircraft that can navigate through the air under its own power. The AFC 402 includes a lifting portion 404, which includes the lighter than air gas, and a fulfillment center 406 which is used to store inventory, deploy UAVs, etc. The fulfillment center may be coupled with the lifting portion using a variety of techniques. For example, as illustrated, the fulfillment center 406 may be suspended using cables from the lifting portion 404 of the AFC 402. In other implementations, the fulfillment center 406 may be directly mounted to or incorporated with the lifting portion 404.

The fulfillment center 406 of the AFC 402 may include one or more UAV deployment bays 408 and one or more docking bays 412. Depending on the configuration of the shuttle 450 and/or the AFC 402, the docking bay 412 and/or docking arm 414 may be utilized. For example, as illustrated, the docking arm 414 has been extended from the AFC 402 and docked or mated to the shuttle 450 to facilitate the transfer of inbound items and outbound items between the AFC 402 and the shuttle 450. As another example, if the lifting portion of the AFC 402 has a toroid shape, the shuttle 450 may navigate through the opening of the toroid and dock with the top of the fulfillment center 406 of the AFC 402.

The airship that is utilized for the AFC 402 may be any type of airship. For example, the airship may be a non-rigid airship, a semi-rigid airship, or a rigid airship. Likewise, the AFC 402 may be of any size, shape and/or configuration. In some implementations, the AFC 402 may be hundreds of feet long and capable of carrying several hundreds of tons. In other implementations, the airship may have the shape of a toroid, a tubular shape, a spherical shape, include multiple portions, etc.

The control of the AFC 402 may be manual (e.g., a pilot) or automated (e.g., directly or remotely controlled by an automated system, robotic, etc.). The AFC 402 may likewise include one or more internal computing systems (not shown), that are capable of maintaining system information for the AFC and/or providing other computing functions. For example, as illustrated, the docking arm 414 has been extended from the AFC 402 and docked or mated to the shuttle 450 to facilitate the transfer of inbound items and outbound items between the AFC 402 and the shuttle 450. As another example, if the lifting portion of the AFC 402 has a toroid shape, the shuttle 450 may navigate through the opening of the toroid and dock with the top of the fulfillment center 406 of the AFC 402.

The airship that is utilized for the AFC 402 may be any type of airship. For example, the airship may be a non-rigid airship, a semi-rigid airship, or a rigid airship. Likewise, the AFC 402 may be of any size, shape and/or configuration. In some implementations, the AFC 402 may be hundreds of feet long and capable of carrying several hundreds of tons. In other implementations, the airship may have the shape of a toroid, a tubular shape, a spherical shape, include multiple portions, etc.

The control of the AFC 402 may be manual (e.g., a pilot) or automated (e.g., directly or remotely controlled by an automated system, robotic, etc.). The AFC 402 may likewise include one or more internal computing systems (not shown), that are capable of maintaining system information for the AFC and/or providing other computing functions. For example, as illustrated, the docking arm 414 has been extended from the AFC 402 and docked or mated to the shuttle 450 to facilitate the transfer of inbound items and outbound items between the AFC 402 and the shuttle 450. As another example, if the lifting portion of the AFC 402 has a toroid shape, the shuttle 450 may navigate through the opening of the toroid and dock with the top of the fulfillment center 406 of the AFC 402.

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The control of the AFC 402 may be manual (e.g., a pilot) or automated (e.g., directly or remotely controlled by an automated system, robotic, etc.). The AFC 402 may likewise include one or more internal computing systems (not shown), that are capable of maintaining system information for the AFC and/or providing other computing functions. For example, as illustrated, the docking arm 414 has been extended from the AFC 402 and docked or mated to the shuttle 450 to facilitate the transfer of inbound items and outbound items between the AFC 402 and the shuttle 450. As another example, if the lifting portion of the AFC 402 has a toroid shape, the shuttle 450 may navigate through the opening of the toroid and dock with the top of the fulfillment center 406 of the AFC 402.
UAV 612 includes eight lifting propellers 602-1, 602-2, 602-3, 602-4, 602-5, 602-6, 602-7, 602-8 spaced about the frame 604 of the UAV. The lifting propellers 602 may be any form of propeller (e.g., graphite, carbon fiber) and of a size sufficient to lift the UAV 612 and any item engaged by the UAV 612 so that the UAV 612 can navigate through the air, for example, to deliver an item. While this example includes eight lifting propellers, in other implementations, more or fewer propellers may be utilized. Likewise, in some implementations, the lifting propellers may be positioned at different locations on the UAV 612. In addition, alternative methods of propulsion may be utilized. For example, fans, jets, turboprops, turbo fans, jet engines, and the like may be used to propel the UAV.

The frame 604 or body of the UAV 612 may likewise be of any suitable material, such as graphite, carbon fiber, and/or aluminum. In this example, the frame 604 of the UAV 612 includes four rigid members 605-1, 605-2, 605-3, 605-4, or beams arranged in a hash pattern with the rigid members intersecting and joined at approximately perpendicular angles. In this example, rigid members 605-1 and 605-3 are arranged parallel to one another and are approximately the same length. Rigid members 605-2 and 605-4 are arranged parallel to one another, yet perpendicular to rigid members 605-1 and 605-3. Rigid members 605-2 and 605-4 are approximately the same length. In some embodiments, all of the rigid members 605 may be of approximately the same length, while in other implementations some or all of the rigid members may be of different lengths. Likewise, the spacing between the two sets of rigid members may be approximately the same or different.

While the implementation illustrated in FIG. 6 includes four rigid members 605 that are joined to form the frame 604, in other implementations, there may be fewer or more components to the frame 604. For example, rather than four rigid members, in other implementations, the frame 604 of the UAV 612 may be configured to include six rigid members. In such an example, two of the rigid members 605-2, 605-4 may be positioned parallel to one another. Rigid members 605-1, 605-3 and two additional rigid members on either side of rigid members 605-1, 605-3 may all be positioned parallel to one another and perpendicular to rigid members 605-2, 605-4. With additional rigid members, additional cavities with rigid members on all four sides may be formed by the frame 604. As discussed further below, a cavity within the frame 604 may be configured to include an item engagement mechanism for the engagement, transport, and delivery of item(s) and/or containers that contain item(s).

In some implementations, the UAV may be configured for aerodynamics. For example, an aerodynamic housing may be included on the UAV that encloses the UAV control system 610, one or more of the rigid members 605, the frame 604, and/or other components of the UAV 612. The housing may be made of any suitable material(s) such as graphite, carbon fiber, aluminum, etc. Likewise, in some implementations, the location and/or the shape of the item engagement mechanism and/or any items or containers may be aerodynamically designed.

In some instances, a container may be utilized for holding an item, wherein the item engagement mechanism engages the item by engaging the container. For example, specially shaped containers for use with the UAV 612 may be aerodynamically designed and provided in the AFC, such that a worker or automated system is able to select one of the containers and place the item in the container for engagement by the UAV 612. The containers may be configured to account for the change in pressure as the UAV descends from the AFC. For example, the container may be a rigid body with one or more openings or baffles that allow pressure to equalize between the interior of the container and the atmosphere around the container. Likewise, the containers may have thermal characteristics to keep items within the containers at a desired temperature. For example, if prepared hot food is being delivered, the container may be designed to keep the food at a desired temperature until the food is delivered to the user.

In some implementations, the item engagement mechanism may be configured such that, when an item and/or container is engaged, it is enclosed within the frame and/or housing of the UAV 612 so that no additional drag is created during transport of the item. In other implementations, the item and/or container may be shaped to reduce drag and provide a more aerodynamic design. For example, if a portion of a container extends below the UAV when engaged, the exposed portion of the container may have a curved shape.

The lifting propellers 602 and corresponding lifting motors are positioned at both ends of each rigid member 605. The lifting motors may be any form of motor capable of generating enough speed with the lifting propellers to lift the UAV 612 and any engaged item thereby enabling aerial transport of the item. For example, the lifting motors may each be a FX-4006-13 740kv multi rotor motor.

Extending outward from each rigid member is a support arm 606 that is connected to a safety barrier 608. In this example, the safety barrier is positioned around and attached to the UAV 612 in such a manner that the motors and propellers 602 are within the perimeter of the safety barrier 608. The safety barrier may be plastic, rubber, etc. Likewise, depending on the length of the support arms 606 and/or the length, number or positioning of the rigid members 605, the safety barrier may be round, oval, or any other shape.

Mounted to the frame 604 is the UAV control system 610. In this example, the UAV control system 610 is mounted in the middle and on top of the frame 604. The UAV control system 610, as discussed in further detail below with respect to FIG. 12, controls the operation, routing, navigation, communication, and the item engagement mechanism of the UAV 612.

The UAV 612 also includes one or more power modules 613. In this example, the UAV 612 includes two power modules 613 that are removably mounted to the frame 604. The power module for the UAV may be in the form of battery power, solar power, gas power, super capacitor, fuel cell, alternative power generation source, or a combination thereof. For example, the power module 613 may each be a 6000 mAh lithium-ion polymer battery, polymer lithium ion (Li-poly, Li-Pol, LiPo, LiP, PLi, or Lip) battery. The power module(s) 613 are coupled to and provide power for the UAV control system 610 and the propeller motors. In some implementations, one or more of the power modules may be configured such that it can be autonomously removed and/or replaced with another power module while the UAV is landed (e.g., such power modules may be provided or replaced while the UAV is landed in a shuttle). In some implementations, when the UAV is within a shuttle or mounted to an exterior of a shuttle, the UAV may engage with a charging member to recharge the power module. In some implementations, when the UAV is descending from the AFC, it may utilize the propellers and corresponding motors as generators to further charge the power modules 613.

As mentioned above, the UAV 612 may also include an item engagement mechanism 614. The item engagement mechanism may be configured to engage and disengage items and/or containers that hold items. In this example, the item engagement mechanism 614 is positioned within a cavity of
the frame 604 that is formed by the intersections of the rigid members 605. The item engagement mechanism may be positioned beneath the UAV control system 610. In implementations with additional rigid members, the UAV may include additional item engagement mechanisms and/or the item engagement mechanism 614 may be positioned in a different cavity within the frame 604. The item engagement mechanism 614 may be of any size sufficient to securely engage and disengage items and/or containers that contain items. In other implementations, the engagement mechanism may operate as the container, containing the item(s) to be delivered. The item engagement mechanism communicates with (via wired or wireless communication) and is controlled by the UAV control system 610.

As will be described in more detail below with respect to FIG. 12, the UAV control system 610 may operate in conjunction with or may otherwise utilize or communicate (e.g., via wired or wireless communication) with one or more components of the inventory management system 126, shuttles, and/or the AFC. Likewise, components of the inventory management system 126, shuttles, and/or the AFC may generally interact and communicate with the UAV control system 610.

While the implementations of the UAV discussed herein utilize lifting propellers to achieve and maintain flight, in other implementations, the UAV may be configured in other manners. In one implementation, the UAV may include fixed wings and/or a combination of both propellers and fixed wings, as illustrated in FIG. 7.

FIG. 7 depicts another view of a UAV 712, according to an implementation. In the example illustrated in FIG. 7, the UAV 712 includes a wing 718 coupled to the frame 704 of the UAV 712. The wing 718 may be configured to rotate or pivot about the frame 704 and positioned above a thrusting motor housing 720 that includes the thrusting motor and thrusting propeller.

The thrusting motor housing 720 may be aerodynamically shaped and configured to encase a thrusting motor and/or a thrusting propeller. The thrusting motor and the thrusting propeller may be the same or different as the lifting motors and lifting propellers 702. For example, in some implementations, the thrusting motor may be a Tiger U-8 motor and the thrusting propeller may have a dimension of eighteen inches. In other implementations, the thrusting motor and the thrusting propeller may be coupled to the top of the frame 704 and positioned above a thrusting motor housing 720 that includes the thrusting motor and thrusting propeller.

FIG. 8 is a flow diagram illustrating an example order delivery selection process 800, according to an implementation. This process, and each process described herein, may be implemented by the architectures described herein or by other architectures. The process is illustrated as a collection of blocks in a logical flow graph. Some of the blocks represent operations that can be implemented in hardware, software, or a combination thereof. In the context of software, the blocks represent computer-executable instructions stored on one or more computer readable media that, when executed by one or more processors, perform the recited operations. Generally, computer-executable instructions include routines, programs, objects, components, data structures, and the like that perform particular functions or implement particular abstract data types.

The computer readable media may include non-transitory computer readable storage media, which may include hard drives, floppy diskettes, optical disks, CD-ROMs, DVDs, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, flash memory, magnetic or optical cards, solid-state memory devices, or other types of storage media suitable for storing electronic instructions. In addition, in some implementations, the computer readable media may include a transitory computer readable signal (in compressed or uncompressed form). Examples of computer readable signals, whether modulated using a carrier or not, include, but are not limited to, signals that a computer system...
hosting or running a computer program can be configured to access, including signals downloaded through the Internet or other networks. Finally, the order in which the operations are described is not intended to be construed as a limitation, and any number of the described operations can be combined in any order and/or in parallel to implement the process.

The example process 800 begins with the receipt of an order for an item, as in 802. Upon receiving an order for an item from a user, a determination is made as to the estimated delivery timeframe for that item, as in 804. In some examples, this may include identifying a materials handling facility and/or AFC with the requested item in stock and estimating the time required to fulfill the item to the user. In other implementations, the estimated delivery timeframe may be a set day from the date of the purchase request or a series of days. For example, a user may specify that the delivery timeframe is to be one day from the date of the purchase request or between three and five days from the date of the purchase request. In still other implementations, the estimated delivery timeframe may be a set day of the week upon which the user has requested to have items delivered. For example, a user may preselect to have items ordered during the week delivered on Thursday of every week. Alternatively, the estimated delivery timeframe may be immediate delivery.

After the estimated delivery timeframe is determined, a determination is made as to whether an AFC is or will be within a delivery area that includes a user specified delivery location, as in 806. As described above, in various implementations, AFCs may be positioned at fulfillment center altitudes and UAVs may be deployed from the AFC to deliver ordered items. Each AFC may have a corresponding delivery range representative of the range or distance a UAV can travel to deliver an item when deployed from the AFC. In some implementations, a delivery location may be within the delivery range of multiple AFCs and/or ground based materials handling facilities. If it is determined that the delivery location is within the range of one or more AFCs, a determination is made as to whether one of the AFCs is selected by the user for delivery, as in 808. In various implementations, an interaction may be received from a user through a user interface that presents delivery options to the user and receives a selection from the user (e.g., for selecting an AFC or other delivery option). In addition, in various implementations, a user may preselect or provide a preference for deliveries from an AFC or other delivery options. In various implementations, different factors may be evaluated for determining whether an AFC will be presented as an option for fulfillment of an item. For example, an AFC's current and/or planned inventory, available capacity, ability to handle items of certain sizes, suitability for delivering certain types of items via UAV (e.g., large and/or heavy items), etc., may all be considered. If the user selects an available AFC, the selected AFC is designated for the delivery of the item, as in 810.

If it is determined that an AFC is not selected for delivery, as in 808, or that no AFCs will be within the range of the delivery location, as in 806, another type of delivery option is designated (e.g., as selected by the user) for the item, as in 812. In various implementations, other delivery options may include traditional carrier deliveries, UAV delivery from a materials handling facility, providing an item at a pickup location where a user may retrieve the item, etc.

FIG. 9 is a flow diagram illustrating an example process 900 for a delivery of an item by a UAV deployed from an AFC, according to an implementation. The example process 900 begins with the UAV engaging the item, as in 902. In various implementations, different types of UAVs may have different methods for engaging an item. For example, as described above with respect to FIG. 6, a UAV may include an inventory engagement mechanism for engaging an item. Likewise, in some implementations, the item may be engaged by the UAV before it is ordered so that the UAV can be deployed for delivery as soon as the item is ordered.

After the item is engaged, the UAV is deployed or otherwise released from the AFC and the UAV begins navigation along a delivery path toward the specified delivery location using little or no power, as in 904. As discussed above, as the UAV descends from the AFC, it may travel in a path that includes a horizontal component using little to no power by manipulating the ailerons of a wing, if so equipped, and/or by selectively engaging the motors and corresponding propellers of the UAV. In various implementations, delivery path instructions may be received by the UAV (e.g., from the AFC, from the inventory management system, from a remote computing resource, etc.).

In some implementations, the UAV may also navigate to avoid any other aircraft, such as commercial aircraft, private aircraft, and/or other UAVs as it descends from the AFC. For example, the UAV may be provided with flight path information of other aircraft and navigate to avoid intersections with those flight paths. In another example, the UAV may monitor for ADS-B signals to detect and avoid nearby aircraft. As the UAV descends, a determination is made as to whether the UAV has entered the UAV network, as in 906. It may be determined that the UAV has entered the UAV network when it is able to communicate with other UAVs, join the UAV network discussed above with respect to FIGS. 2 and 3, has reached a defined altitude, etc. If the UAV has not entered the UAV network, the example process 900 returns to block 904 and continues. Once it is determined that the UAV has entered the UAV network, the UAV may engage the motors and corresponding propellers of the UAV to slow descent of the UAV and to complete navigation of the UAV along the delivery path to the delivery location, as in 909.

In some implementations, the UAV may receive additional information (e.g., weather) from UAVs of the UAV network and/or detect obstacles as it navigates toward the delivery location. As it receives information and/or detects obstacles, the UAV may alter the delivery path that is followed to the delivery location. When the UAV arrives at the delivery location, the ordered item is disengaged from the UAV to complete the delivery of the item, as in 910. After the UAV has disengaged the item, a confirmation of the delivery is sent from the UAV, as in 912. In various implementations, the confirmation of the delivery of the item may be received by the AFC, the inventory management system, a remote computing resource, other UAVs, etc., and may be utilized for updating the status in the inventory management system regarding the delivery of the item, planning inventory for the AFC, for providing a notification to a user regarding the delivery, etc.

Once the confirmation of the delivery has been sent, a determination is made as to whether the UAV will navigate to a shuttle for a trip back to the AFC or another AFC, as in 914. If the UAV is to return to the AFC, the UAV receives return path instructions identifying a location of a shuttle replenishment location at which a shuttle is or will be positioned that the UAV may utilize to travel upon back to the AFC. Accordingly, the UAV will navigate along the return path to the shuttle replenishment location and land or otherwise be placed into a shuttle for return to the AFC, as in 916. If the UAV is not to return to the AFC or another AFC, the UAV returns to another designated location, as in 918. For
example, the UAV may be instructed to navigate to a ground based materials handling facility within the range of the UAV.

In various implementations, certain portions of the example process 900 may be repeated, in particular with regard to deliveries of multiple items. For example, if a UAV is carrying multiple items that are to be delivered to different delivery locations, the UAV may travel from one delivery location to another before navigating to a shuttle or another designated location.

The UAV item delivery process for delivering items using a UAV deployed from an AFC provides the ability for users to receive items quickly and with limited transportation costs. For example, for items stocked in inventory at the AFC, the user may place an order for an item and have the item delivered within ten minutes or less, in some examples. Likewise, through the use of UAVs, the items can be delivered to virtually any user specified delivery location. For example, a user may select to have the item delivered directly to the location of the user. In such an example, location information may be determined and utilized as the location of the user. For example, the GPS information of the user's portable device may be utilized as the location of the user and the item delivered to a location near the GPS position of the user's portable device. If the user moves to a different location after ordering the item, the position of the user may be updated and the UAV may update its navigation path based on the current location of the user.

Likewise, with the speed of item delivery available from the implementations discussed herein, a large variety of items may be delivered to a user. In one example, the AFC may include a food preparation area and a user may order prepared food (such as a meal). The ordered food may be prepared, placed in a container and delivered directly to the user from the AFC using a UAV. The container may be configured to keep the food at the desired temperature (hot or cold) until delivery. Any other type of item that may be carried by a UAV may likewise be delivered using the implementations discussed herein. In some implementations, the AFC may be utilized to promote or advertise items and/or to fulfill an order. For example, the AFC may compensate to deliver the items associated with the advertisement have been sold, etc.), the AFC may terminate presentation of the advertisement, the quantity remaining may be updated to reflect the sold item.

A determination is also made as to whether the advertisement is to continue, as in 1010. For example, the advertisement may be scheduled to be presented for a defined period of time, until a defined quantity of the advertised item has been sold, and/or based on other factors. If it is determined that the advertisement is not to continue (e.g., the time duration of the advertisement has expired, the quantity of items associated with the advertisement have been sold, etc.), the AFC may terminate presentation of the advertisement and navigate from the advertising altitude, as in 1012. For example, the AFC may navigate back up to the fulfillment center altitude where the AFC was previously positioned, the AFC may land, etc. After navigating from the advertising altitude, the example process 1000 completes, as in 1014.

Utilizing the AFC to advertise items for immediate delivery provides additional flexibility in inventory management and item promotion. For example, if it is determined that an item is overstocked at the AFC, rather than sending the items to another location using a shuttle, the items may be advertised at a reduced price to deplete the overstock of inventory. Likewise, if the AFC is scheduled to land for service, restocking and/or for other purposes, as part of the descent toward landing, the AFC may navigate to an advertisement altitude and advertise the sale of one or more of the items currently in inventory of the AFC.

As inventory, UAVs, supplies, etc., are depleted from the AFC, and/or during times of low activity, the AFC may descend and land. Alternatively, as discussed herein, shuttles may be utilized to deliver inbound items to the AFC so that the AFC can remain airborne for extended periods of time. FIG. 11 is a flow diagram of an example shuttle process 1100, according to an implementation. The example process 1100 begins when a shuttle is positioned on the ground at a shuttle replenishment location. A shuttle replenishment location may be any designated location at which a shuttle may be positioned. As part of the example process 1100, inbound items that are to be transported to the AFC are loaded onto the shuttle, as in 1102. Inbound items may be any item that is to be transported to the AFC. For example, inbound items may be inventory, UAV, workers, fuel, supplies, contractors, etc. In some implementations, as discussed above, a shuttle may hold a variety of different types of inbound items. In other implementations, shuttles may be designed for one or more types of inbound items. For example, some shuttles may be partially or entirely designated for UAV transport. Such shuttles may be configured with charging stations to enable charging of UAVs during the transport from the shuttle replenishment location.
location to the AFC. Likewise, tools and/or personnel necessary to service or repair UAVs may also be included on the shuttle. In other examples, shuttles may be partially or entirely designated for inventory transport and/or people (e.g., workers) transport. For example, some shuttles may include seats, safety equipment, etc., to ensure the safe transport of humans to and from the AFC.

As the shuttle is loaded with inbound items, a determination is made as to whether the shuttle is to depart for the AFC, as in 1104. Determining whether to depart for the AFC may be based on a variety of factors including, but not limited to, the type of inbound items being transported, the capacity of the shuttle, the need for the inbound items at the AFC, etc. For example, if the shuttle is used to transport workers to the AFC, the shuttle may be scheduled to depart the shuttle replenishment location at a designated time. Once the designated time is reached, the shuttle may depart. In another example, if the shuttle is transporting inventory and/or fuel, the need for the loaded inventory and/or the fuel at the AFC may be determined. If additional inventory, fuel and/or other items are in-route to the shuttle replenishment location, the estimated time until arrival of the additional inbound items may likewise be considered. Still further, the time until the next shuttle departure may likewise be considered in determining whether the shuttle is to depart for the AFC.

If it is determined that the shuttle is not to depart for the AFC, the example process 1100 returns to block 1102 and continues. If it is determined that the shuttle is to depart for the AFC, the shuttle departs the shuttle replenishment location and navigates to the AFC, as in 1105. The shuttle may be manually navigated to the AFC by an operator of the shuttle, navigated using automated controls and/or a combination thereof. As the shuttle navigates to the AFC, inbound items may be serviced. For example, UAVs may be charged by the shuttle, serviced and/or repaired as they are transported to the AFC.

When the shuttle arrives at the AFC, it is secured to and docked with the AFC, as in 1106. Securing and docking of the shuttle may be accomplished in a variety of manners depending on the shape and configuration of the AFC and the UAV. For example, a docking arm may extend from the AFC and/or the shuttle and mate the shuttle to the AFC, thereby securing the position of the shuttle with respect to the AFC and providing a channel through which inbound items may be transported from the shuttle to the AFC. In other implementations, the AFC may include a hangar or other opening into which the shuttle may navigate and become fully or partially enclosed within the AFC. As will be appreciated, any type of docking techniques may be utilized with the implementations discussed herein.

Upon docking and securing of the shuttle with the AFC, the inbound items are unloaded from the shuttle into the AFC, as in 1108. For example, inventory may be transported from the shuttle to a receiving location of the AFC where the items are inducted into inventory of the AFC and made available for picking and delivery. Likewise, the UAVs may be moved from the shuttle to a UAV staging area within the AFC where they may be serviced, charged, etc., while awaiting deployment instructions. Workers or other humans may likewise disembark from the shuttle into the AFC.

Once the inbound items to be delivered to the AFC have been removed from the shuttle, a determination is made as to whether outbound items are to be loaded onto the shuttle before the shuttle departs the AFC, as in 1110. Outbound items are any items that can be carried by the shuttle that are to be removed from the AFC. For example, outbound items may include overstock inventory, inventory that is to be shipped to another AFC or a ground based materials handling facility (referred to herein as transship inventory), damaged items, waste, workers, etc.

If it is determined that outbound items are to be loaded onto the AFC, the outbound items are loaded, as in 1112. As with inbound items, in some implementations, the shuttles may be designed for particular types of outbound items. For example, some shuttles may be configured to receive waste, damaged items, overstocked items and/or transshipments, while other shuttles may only receive humans. In some implementations, the destination of the shuttle after it departs the AFC may be considered when determining whether to load outbound items. For example, in some implementations, the shuttle may navigate to multiple AFCs delivering inbound items before the shuttle returns to earth. In such an example, non-humans may be loaded onto the shuttle and/or humans that are to be transported to another AFC may be loaded.

After the inbound items have been loaded, or if it is determined that the shuttle is not to depart for the AFC, the example process 1110 that no outbound items are to be loaded, the shuttle undocks from the AFC and navigates to a next scheduled destination, the shuttle replenishment location, another AFC, as in 1114. In some implementations, similar to determining when a shuttle is to depart a shuttle replenishment location, a similar determination may be made as to when/whether a shuttle is to depart the AFC.

FIG. 12 is a block diagram illustrating an example UAV control system 1210 that may be utilized with any of the UAVs discussed herein, such as the UAV 612 of FIG. 6 or the UAV 712 of FIG. 7. In various examples, the block diagram may be illustrative of one or more aspects of the UAV control system 1210 that may be used to implement the various systems and methods discussed herein and/or to control operation of the UAV. In the illustrated implementation, the UAV control system 1210 includes one or more processors 1202, coupled to a memory, e.g., a non-transitory computer readable storage medium 1220, via an input/output (I/O) interface 1211. The UAV control system 1210 may also include motors controllers 1204, such as electronic speed controls (ESCs), power supply modules 1206 and/or a navigation system 1208. The UAV control system 1210 further includes an inventory engagement controller 1213, a network interface 1216, and one or more input/output devices 1218.

In various implementations, the UAV control system 1210 may be a uniprocessor system including one processor 1202, or a multiprocessor system including several processors 1202 (e.g., two, four, eight, or another suitable number). The processor(s) 1202 may be any suitable processor capable of executing instructions. For example, in various implementations, the processor(s) 1202 may be general-purpose or embedded processors implementing any of a variety of instruction set architectures (ISAs), such as the x86, PowerPC, SPARC, or MIPS ISAs, or any other suitable ISA. In multiprocessor systems, each processor(s) 1202 may commonly, but not necessarily, implement the same ISA.

The non-transitory computer readable storage medium 1220 may be configured to store executable instructions, data, flight paths, flight control parameters, component adjustment information, center of gravity information, and/or data items accessible by the processor(s) 1202. In various implementations, the non-transitory computer readable storage medium 1220 may be implemented using any suitable memory technology, such as static random access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory. In the illustrated implementation, program instructions and data implementing desired functions, such as those described herein, are shown stored within the non-transitory computer readable storage medium 1220.
medium 1220 as program instructions 1222, data storage 1224 and flight controls 1226, respectively. In other implementations, program instructions, data and/or flight controls may be received, sent or stored upon different types of computer-accessible media, such as non-transitory media, on similar media separate from the non-transitory computer readable storage medium 1220 or the UAV control system 1210. Generally speaking, a non-transitory, computer readable storage medium may include storage media or memory media such as magnetic or optical media, e.g., disk or CD/DVD-ROM, coupled to the UAV control system 1210 via the I/O interface 1211. Program instructions and data stored via a non-transitory computer readable medium may be transmitted by transmission media or signals such as electrical, electromagnetic, or digital signals, which may be conveyed via a communication medium such as a network and/or a wireless link, such as may be implemented via the network interface 1216.

In one implementation, the I/O interface 1211 may be configured to coordinate I/O traffic between the processor(s) 1202, the non-transitory computer readable storage medium 1220, and any peripheral devices, the network interface or other peripheral interfaces, such as input/output devices 1218. In some implementations, the I/O interface 1211 may perform any necessary protocol, timing or other data transformations to convert data signals from one component (e.g., non-transitory computer readable storage medium 1220) into a format suitable for use by another component (e.g., processor(s) 1202). In some implementations, the I/O interface 1211 may include support for devices attached through various types of peripheral buses, such as a variant of the Peripheral Component Interconnect (PCI) bus standard or the Universal Serial Bus (USB) standard, for example. In some implementations, the function of the I/O interface 1211 may be split into two or more separate components, such as a north bridge and a south bridge, for example. Alternatively, in some implementations, some or all of the functionality of the I/O interface 1211, such as an interface to the non-transitory computer readable storage medium 1220, may be incorporated directly into the processor(s) 1202.

The motor controllers 1204 communicate with the navigation system 1208 and adjust the rotational speed of each lifting motor and/or the thrusting motor to stabilize the UAV and guide the UAV along a determined flight path. The navigation system 1208 may include a global positioning system (GPS), indoor positioning system (IPS), or other similar system and/or sensors that can be used to navigate the UAV to and/or from a location. The information inventory controller 1213 communicates with the actuator(s) or motor(s) (e.g., a servomotor) used to engage and/or disengage items. The network interface 1216 may be configured to allow data to be exchanged between the UAV control system 1210, other devices attached to a network, such as other computer systems (e.g., remote computing resources), and/or with UAV control systems of other UAVs. For example, the network interface 1216 may enable communication between the UAV and a UAV control system that is implemented on one or more remote computing resources. For wireless communication, an antenna of a UAV or other communication components may be utilized. As another example, the network interface 1216 may enable wireless communication between numerous UAVs. In various implementations, the network interface 1216 may support communication via wireless general data networks, such as a Wi-Fi network. For example, the network interface 1216 may support communication via telecommunications networks, such as cellular communication networks, satellite networks, and the like.

Input/output devices 1218 may, in some implementations, include one or more displays, imaging devices, thermal sensors, infrared sensors, time of flight sensors, accelerometers, pressure sensors, weather sensors, etc. Multiple input/output devices 1218 may be present and controlled by the UAV control system 1210. One or more of these sensors may be utilized to assist in landing as well as to avoid obstacles during flight.

As shown in FIG. 12, the memory may include program instructions 1222, which may be configured to implement the example processes and/or sub-processes described herein. The data storage 1224 may include various data stores for maintaining data items that may be provided for determining flight paths, landing, identifying locations for disengaging items, etc. In various implementations, the parameter values and other data illustrated herein as being included in one or more data stores may be combined with other information not described or may be partitioned differently into more, fewer, or different data structures. In some implementations, data stores may be physically located in one memory or may be distributed among two or more memories.

Those skilled in the art will appreciate that the UAV control system 1210 is merely illustrative and is not intended to limit the scope of the present disclosure. In particular, the control system may include any combination of hardware or software that can perform the indicated functions. The UAV control system 1210 may also be connected to other devices that are not illustrated, or instead may operate as a stand-alone system. In addition, the functionality provided by the illustrated components may, in some implementations, be combined in fewer components or distributed in additional components. Similarly, in some implementations, the functionality of some of the illustrated components may not be provided and/or other additional functionality may be available.

Those skilled in the art will also appreciate that, while various items are illustrated as being stored in memory or storage while being used, these items or portions of them may be transferred between memory and other storage devices for purposes of memory management and data integrity. Alternatively, in other implementations, some or all of the software components may execute in memory on another device and communicate with the illustrated UAV control system 1210. Some or all of the system components or data structures may also be stored (e.g., as instructions or structured data) on a non-transitory, computer-accessible medium or a portable article to be read by an appropriate drive. In some implementations, instructions stored on a computer-accessible medium separate from the UAV control system 1210 may be transmitted to the UAV control system 1210 via transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as a wireless link. Various implementations may further include receiving, sending or storing instructions and/or data implemented in accordance with the foregoing description upon a computer-accessible medium. Accordingly, the techniques described herein may be practiced with other UAV control system configurations.

FIG. 13 is a pictorial diagram of an illustrative implementation of a server system 1320 that may be used in the implementations described herein. The server system 1320 may include a processor 1300, such as one or more redundant processors, a video display adapter 1302, a disk drive 1304, an input/output interface 1306, a network interface 1308, and a memory 1312. The processor 1300, the video display adapter 1302, the disk drive 1304, the input/output interface
1306, the network interface 1308, and/or the memory 1312 may be communicatively coupled to each other by a communication bus 1310.

The video display adapter 1302 provides display signals to a display (not shown in FIG. 13) permitting an agent of the server system 1320 to monitor and configure operation of the server system 1320 and/or to provide information (e.g., regarding transportation and/or storage of an item by the AFC, shuttle and/or UAV). The input/output interface 1306 likewise communicates with external input/output devices not shown in FIG. 13, such as a mouse, keyboard, scanner, or other input and output devices that can be operated by an agent of the server system 1320. The network interface 1308 includes hardware, software, or any combination thereof, to communicate with other computing devices. For example, the network interface 1308 may be configured to provide communications between the server system 1320 and other computing devices, such as that of an AFC, materials handling facility, delivery location, UAV and/or shuttle, via a network.

The memory 1312 generally comprises random access memory (RAM), read-only memory (ROM), flash memory, and/or other volatile or permanent memory. The memory 1312 is shown storing an operating system 1314 for controlling the operation of the server system 1320. A binary input/output system (BIOS) 1316 for controlling the low/level operation of the server system 1320 is also stored in the memory 1312.

The memory 1312 additionally stores program code and data for providing network services to the AFC, shuttle, UAV, materials handling facility, and/or the inventory management system. The program instructions enable communication with a data store manager application 1321 to facilitate data exchange between the data store 1309 and the inventory management system.

As used herein, the term “data store” refers to any device or combination of devices capable of storing, accessing, and retrieving data, which may include any combination and number of data servers, databases, data storage devices and data storage media, in any standard, distributed or clustered environment. The server system 1320 can include any appropriate hardware and software for integrating with the data store 1309 as needed to execute aspects of one or more applications for an AFC, shuttle, materials handling facility, delivery location, UAV, and/or the inventory management system.

The data store 1309 can include several separate data tables, databases or other data storage mechanisms and media for storing data relating to a particular aspect. For example, the illustrated data store 1309 includes mechanisms for maintaining information related to operations, inventory, maps, GPS data, etc., which can be used to generate and deliver information to an AFC, shuttle, UAV, and/or inventory management system 1326. It should be understood that there might be additional aspects that can be stored in the data store 1309 and that additional data stores beyond the one illustrated may be included. The data store 1309 is operable, through logic associated therewith, to receive instructions from the server system 1320 and obtain, update or otherwise process data in response thereto.

The memory 1312 may also include the inventory management system 1326, discussed above. The inventory management system 1326 may be executable by the processor 1300 to implement one or more of the functions of the server system 1320. In one implementation, the inventory management system 1326 may represent instructions embodied in one or more software programs stored in the memory 1312. In another implementation, the inventory management system 1326 can represent hardware, software instructions, or a combination thereof.

The server system 1320, in one implementation, is a distributed environment utilizing several computer systems and components that are interconnected via communication links, using one or more computer networks or direct connections. However, it will be appreciated by those of ordinary skill in the art that such a system could operate equally well in a system having fewer or a greater number of components than are illustrated in FIG. 13. Thus, the depiction in FIG. 13 should be taken as being illustrative in nature and not limiting to the scope of the disclosure.

Those skilled in the art will appreciate that in some implementations the functionality provided by the processes and systems discussed above may be provided in alternative ways, such as being split among more software modules or routines or consolidated into fewer modules or routines. Similarly, in some implementations, illustrated processes and systems may provide more or less functionality than is described, such as when other illustrated processes instead lack or include such functionality respectively, or when the amount of functionality that is provided is altered. In addition, while various operations may be illustrated as being performed in a particular manner (e.g., in serial or in parallel) and/or in a particular order, those skilled in the art will appreciate that, in other implementations, the operations may be performed in other orders and in other manners. Those skilled in the art will also appreciate that the data structures discussed above may be structured in different manners, such as by having a single data structure split into multiple data structures or by having multiple data structures consolidated into a single data structure. Similarly, in some implementations, illustrated data structures may store more or less information than is described, such as when other illustrated data structures instead lack or include such information respectively, or when the amount or types of information that is stored is altered. The various methods and systems as illustrated in the figures and described herein represent example implementations. The methods and systems may be implemented in software, hardware, or a combination thereof in other implementations. Similarly, the order of any method may be changed and various elements may be added, reordered, combined, omitted, modified, etc., in other implementations.

From the foregoing, it will be appreciated that, although specific implementations have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the appended claims and the elements recited therein. In addition, while certain aspects are presented below in certain claim forms, inventors contemplate the various aspects in any available claim form. For example, while only some aspects may currently be recited as being embodied in a computer readable storage medium, other aspects may likewise be so embodied. Various modifications and changes may be made as would be obvious to a person skilled in the art having the benefit of this disclosure. It is intended to embrace all such modifications and changes and, accordingly, the above description is to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A computer implemented method, comprising:
   - under control of one or more computing systems configured with executable instructions;
   - receiving an order for an item from a user located in a metropolitan area, wherein the item is maintained in an inventory of an aerial fulfillment center ("AFC") that is airborne at an altitude;
instructing an unmanned aerial vehicle ("UAV") located in the AFC to engage the item; instructing the UAV to depart the AFC; and instructing the UAV to navigate to a delivery location within the metropolitan area and disengage the item at the delivery location.

2. The computer implemented method of claim 1, further comprising:
instructing the UAV to navigate to a shuttle replenishment location and land in a shuttle after the item has been disengaged, wherein the shuttle transports the UAV to the AFC while the AFC is airborne.

3. The computer implemented method of claim 1, wherein at least a portion of the navigation to the delivery location is part of a descent from the AFC and the UAV utilizes reduced power during at least a portion of the descent.

4. The computer implemented method of claim 3, wherein the UAV includes a wing and is configured to glide toward the delivery location as it descends.

5. The computer implemented method of claim 1, further comprising:
instructing, as the UAV enters a UAV network, the UAV to engage one or more motors of the UAV to slow a descent of the UAV and provide lift for the UAV to complete navigation to the delivery location.

6. A system for delivering an ordered item to a user, the system comprising:
an aerial fulfillment center ("AFC") that is airborne at an altitude and configured to receive and store a plurality of inventory items; a shuttle configured to transport inbound items to the AFC while the AFC is airborne; a plurality of UAVs located at the AFC and configured to transport items from the AFC to delivery locations, while the AFC is airborne; and an inventory management system that sends an instruction directing a UAV of the plurality of UAVs to transport the ordered item from the AFC to a delivery location while the AFC is airborne.

7. The system of claim 6, wherein the AFC is further configured to descend from the AFC at a reduced power level while navigating toward the delivery location.

8. The system of claim 6, wherein the AFC includes an airship and is positioned at an altitude above a commercial airspace.

9. The system of claim 6, wherein the shuttle includes an airship and is configured to travel to and from the AFC while the AFC is airborne.

10. The system of claim 6, wherein the inbound items include at least one of a UAV, an inventory item, supplies, fuel, materials handling equipment, or humans.

11. The system of claim 6, wherein:
the shuttle is further configured to transport outbound items from the AFC; and the outbound items include at least one of overstock inventory, transshipment inventory, damaged inventory, waste, materials handling equipment, or humans.

12. The system of claim 6, further comprising:
a UAV network including a plurality of UAVs at an altitude lower than the AFC, wherein the plurality of UAVs are configured to deliver inventory items to users.

13. The system of claim 6, wherein the UAV is further configured to at least:
disengage the ordered item at the delivery location; and navigate to a shuttle replenishment location that includes a shuttle, wherein the shuttle is configured to transport the UAV back to the AFC.

14. The system of claim 6, wherein the AFC is further configured to at least:
present an advertisement for a second item maintained in an inventory of the AFC; receive a second order for the second item; deploy a UAV of the plurality of UAVs from the AFC to deliver the second item while the AFC is airborne; and update the advertisement.

15. A non-transitory computer-readable storage medium storing instructions, the instructions when executed by a processor causing the processor to at least:
receive an order for an item; determine a delivery location for the item; determine an aerial fulfillment center ("AFC") within a range of the delivery location, wherein the AFC is airborne at an altitude and configured to enable delivery of items using unmanned aerial vehicles ("UAV") deployed from the AFC; and designating the AFC for delivery of the item.

16. The non-transitory computer-readable storage medium of claim 15, wherein the instructions when executed by the processor further cause the processor to deploy a UAV that includes the item from the AFC.

17. The non-transitory computer-readable storage medium of claim 16, wherein the instructions when executed by the processor further cause the processor to instruct the UAV to at least:
navigate to the delivery location and disengage the item at the delivery location; and navigate from the delivery location to a shuttle replenishment location that includes a shuttle that will transport the UAV back to the AFC.

18. The non-transitory computer-readable storage medium of claim 17, wherein the instructions when executed by the processor further cause the processor to instruct the shuttle to at least:
receive a plurality of inbound items to be transported to the AFC while the AFC is airborne, wherein the inbound items include at least one of inventory, the UAV, a human, supplies, materials handling equipment, or fuel; depart a shuttle replenishment location and navigate to the AFC while the AFC is airborne; and dock with the AFC so that the inbound items can be unloaded from the shuttle to the AFC to replenish the AFC while the AFC is airborne.

19. The non-transitory computer-readable storage medium of claim 17, wherein the instructions when executed by the processor further cause the processor to instruct the shuttle to at least:
receive a plurality of outbound items to be transported from the AFC while the AFC is airborne, wherein the outbound items include at least one of overstock inventory, transshipment inventory, damaged inventory, waste, materials handling equipment, or a human; and depart the AFC while the AFC is airborne.

20. The non-transitory computer-readable storage medium of claim 17, wherein the instructions when executed by the processor further cause the processor to instruct the UAV to at least:
navigate to the delivery location and disengage the item at the delivery location; and navigate from the delivery location to a ground-based materials handling facility.
ANEXO 3
PLANOS DE CONDICIONES URBANAS
CONDICIONES URBANAS
INDUSTRIA
- naves, almacenes, fábricas -
TFC Palacios A. D
Ciudadela Marcou
En base a los parámetros estudados y teniendo en cuenta que la autonomía de los drones que propone Amazon es de unos 30 km, se plantean tres posibles localizaciones de la columna dentro de Madrid. Se mason las áreas de abastecimiento de cada una de las localizaciones y se procede al análisis de viabilidad de cada una de ellas.

Localización 1. Castellana monumental

La planta magna propuesta propone hacer un eje de los cuatro puntos, localizando la torre en el norte de la ciudad.

Análisis de la localización.
- Tiene un buen alcance territorial, pero se necesita a la Almudena y a la Real Fábrica de Paños. Algunos puntos de la turística se encuentran a buena distancia. Se garantiza el abastecimiento de Madrid sin perder parte del turismo de las Artes.

Localización 2. Cementerio de la Almudena

Con el cementerio de la Almudena de fondo, se propone colocar la columna en la salida de Madrid y en la mejor localización para los lugares de abastecimiento.

Análisis de la localización.
- El eje queda concentrado en la base de Amazon con gran de España. San Fernando de Henares.
- "Corre de O'Hara" por la expansión de este núcleo de las Artes.

Localización 3. Amazon en colmenar

Haciendo el plan urbanístico de Ana Botella se plantea la extensión en la zona de calles del sistema central, que cubra a ambos el núcleo de colmenar.

Análisis de la localización.
- Abarca con la base sur de Madrid, sobre la gobernanza de las Artes industriales. "Corre de O'Hara" por la expansión de este núcleo de las Artes.
- Se garantiza a todo un tránsito de los municipios, ahora el solo llegar a casa en unas casas de madera. -No se garantiza la seguridad del acceso mediante ferrocarril.

CONDICIONES URBANAS
SUPERPOSICIÓN
Fases de diseño
TIC Pasajes 4.0
Creado en Mapeo