Title: BICYCLE SPACE AVAILABILITY AND CHECK-IN SYSTEM FOR PUBLIC TRANSIT

Abstract: Methods, systems, and apparatuses for determining bicycle space availability and bicycle space check-in are described. A plurality of space sensors are provided with each space sensor being configured to monitor occupancy of a bicycle space and generate a data output signal indicating occupancy status. A hub controller is provided that is configured to receive the data output signal from each of the plurality of space sensors, generate bicycle space information for a transit unit, and communicate the bicycle space information to a server.
BICYCLE SPACE AVAILABILITY AND CHECK-IN SYSTEM FOR PUBLIC TRANSIT

TECHNICAL FIELD

[0001] The disclosure relates generally to methods, systems, and apparatuses for determining bicycle space availability and bicycle space check-in on public transit and public transit systems.

BACKGROUND

[0002] Bicycles can provide a convenient, less costly and healthy mode of transportation. Although pure bicycle trips for commuting remains a key source, most large city commuters have adopted a mixed-modal approach that requires them to bicycle for a certain part, hop on a public transit system, and finish the final leg by bicycling again. People who adopt this form of transportation regularly, in combination with public transit services to get around or to commute to work or other locations and back, have to face the possibility of missing their commute because there is no space available for their bicycle on the public transit system. It will be appreciated that individual cars or units of a transit vehicle in a public transit system may be referred to as "coaches" or "units."

[0003] In the San Francisco Bay Area for example, CALTRAIN provides bicycle-only coaches where commuters may dock their bicycles during their trips. During rush hour, there is limited space availability for the number of bicycles that can be stowed on the train. In the case when there is no space available for the bicycle, the person would have to miss the desired public transit train and wait for a future train with no guarantees of availability on the next one. Multimodal commuters need to have a mechanism to find out the availability of bicycle spaces on public transit systems prior to their trips. Previous solutions exist for bicycle space garages to
determine bicycle space availability using an image processing technology. However, these previous solutions do not allow commuters to determine, in advance, availability of bicycle space on public transit coaches.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0004] Non-limiting and non-exhaustive implementations of the present disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified. Advantages of the present disclosure will become better understood with regard to the following description and accompanying drawings where:

[0005] FIG. 1 illustrates an implementation of a user interface of a mobile application on a mobile device;

[0006] FIG. 2 illustrates an implementation of a user interface of a mobile application on a mobile device;

[0007] FIG. 3 illustrates an overhead view of a transit unit comprising a check-in and bicycle space availability system;

[0008] FIG. 4 illustrates a schematic view of computing hardware for an implementation of a check-in and bicycle space availability system;

[0009] FIG. 5 illustrates a schematic view of computing hardware for an implementation of a check-in and bicycle space availability system;

[0010] FIG. 6 illustrates a schematic view of computing networks and hardware for an implementation of a check-in and bicycle space availability system; and
FIG. 7 illustrates a flow chart of an example method according to one implementation of the social application platform.

DETAILED DESCRIPTION

[0012] The methods and systems disclosed herein provide a bicycle check-in system for public transit systems, such as trains that have special coaches for docking bicycles. The system senses the number of bicycles docked in bicycle spaces on a particular transit unit, such as a coach, and the number of open bicycle spaces that are available. This information regarding the open bicycle spaces may be communicated to users via a website or mobile app, thereby allowing the users to plan trips on mass transit systems based on the availability of bicycle spaces on specific transit units.

[0013] According to one method for determining availability of bicycle space, a plurality of bicycle spaces may be monitored. At least one bicycle space of the plurality of bicycle spaces that is occupied by a bicycle is determined from the monitoring. Bicycle space availability information may then be generated that includes an indication that at least one bicycle space is occupied. Further, unoccupied bicycle spaces, which are included as part of the plurality of bicycle spaces, may be indicated as available in an output signal. Furthermore, the bicycle space availability information may be transmitted to a device. A graphic may allow a user to view the bicycle space availability information on the device when selecting a transit unit for travel. In an implementation of the disclosure, a bicycle space availability determining system may comprise a sensor system and a bicycle space availability hub controller. The sensor system may be configured to monitor a plurality of bicycle spaces. The sensor system comprises at least one sensor element that generates a sensor data output signal to be received by a hub controller. The
hub controller may then generate bicycle space availability information. The hub controller may be configured to calculate and determine (based on the received sensor data output signal) that at least one bicycle space of the plurality of bicycle spaces is occupied as well as how many spaces are unoccupied and available or potentially available. The hub controller may further be configured to include an indication in the bicycle space availability information that the at least one bicycle space is occupied as previously determined by the sensor system and the hub controller. If one or more unoccupied bicycle spaces are included in the plurality of bicycle spaces, then an indication is included in the bicycle space availability information that the unoccupied bicycle spaces are available for bicycle parking for that particular transit route. Furthermore, the system may include a communication interface configured to transmit the generated bicycle space availability information to a requesting device.

[0014] In the following disclosure, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific implementations in which the disclosure may be practiced. It is understood that other implementations may be utilized and structural changes may be made without departing from the scope of the present disclosure. References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.
A potential advantage of having a check-in system is that multi-mode commuters who travel on bicycles and public transit systems will have access to information about the availability of bicycle spaces on individual public transit units or coaches as they prepare for their trips. Embodiments of the present disclosure relate to a check-in system for cyclists for determining whether there is bicycle space available on specific public transit units or coaches. In an embodiment, a bicycle space availability determination may be made in substantially "real time." The ability to determine availability of bicycle spaces on a public transit unit in substantially real time can be very useful for a user, because bicycle space can vary based on transit stop, time of day, and proximity to a specific destination. The substantially real time bicycle space information enables users to choose transit units under constantly changing bicycle space conditions. An implementation of a public transit bicycle space availability system may comprise one or more sensors for detecting the presence of a bicycle and rider in a designated bicycle space within a transit unit. As used herein the term "transit unit" is intended to denote such things as trains, individual train cars, individual train coaches, cable cars, buses, ferries, light rail trains, subways, etc. For example, a train may comprise a plurality of transit units, wherein each car of the train is considered a separate transit unit. The one or more sensors may generate data regarding whether a bicycle space is occupied or available using wireless technologies to report space availability in real-time to a local hub controller that is on-board each public transit unit. In an implementation, a hub controller may receive information from one sensor corresponding to one bicycle space or from multiple sensors corresponding to multiple bicycle spaces. Additionally, the hub controller may be configured to package the individual sensor data and then transmit the packaged information to a remote central
management server that is configured to provide bicycle space information to a website and/or to a mobile app.

[0016] In an implementation not comprising sensors in each bicycle space, a user may manually check-in through a mobile application, or the system may count (or otherwise monitor) cyclists as they pass through thresholds of the transit unit.

[0017] Implementations of the public transit bicycle space availability system in the present disclosure may comprise or utilize a special purpose or general-purpose computer including computer hardware, such as, for example, one or more processors and system memory, as discussed in greater detail below. Implementations within the scope of the present disclosure may also include physical and other computer-readable media for carrying or storing computer-executable instructions and/or data structures. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer system. Computer-readable media that store computer-executable instructions are computer storage media (devices). Computer-readable media that carry computer-executable instructions are transmission media. Thus, by way of example, and not limitation, implementations of the disclosure can comprise at least two distinctly different kinds of computer-readable media: computer storage media (devices) and transmission media.

[0018] Computer storage media (devices) includes RAM, ROM, EEPROM, CD-ROM, solid state drives ("SSDs") (e.g., based on RAM), Flash memory, phase-change memory ("PCM"), other types of memory, other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer.
An implementation of the public transit bicycle space availability system may communicate over a computer network. A "network" is defined as one or more data links that enable the transport of electronic data between computer systems and/or modules and/or other electronic devices. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computer, the computer properly views the connection as a transmission medium. Transmissions media can include a network and/or data links which can be used to carry desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer. Combinations of the above should also be included within the scope of computer-readable media.

Computer-executable instructions comprise, for example, instructions and data which, when executed at a processor, cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions. The computer executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, or even source code. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the described features or acts described above. Rather, the described features and acts are disclosed as example forms of implementing the claims.

Those skilled in the art will appreciate that the disclosure may be practiced in network computing environments with many types of computer system configurations, including, personal computers, desktop computers, laptop computers, message processors, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics,
network PCs, minicomputers, mainframe computers, mobile telephones, PDAs, tablets, pagers, routers, switches, various storage devices, and the like. The disclosure may also be practiced in distributed system environments where local and remote computer systems, which are linked (either by hardwired data links, wireless data links, or by a combination of hardwired and wireless data links) through a network, both perform tasks. In a distributed system environment, program modules may be located in both local and remote memory storage devices.

[0022] Further, where appropriate, functions described herein can be performed in one or more of: hardware, software, firmware, digital components, or analog components. For example, one or more application specific integrated circuits (ASICs) can be programmed to carry out one or more of the systems and procedures described herein. Certain terms are used throughout the following description and Claims to refer to particular system components. As one skilled in the art will appreciate, components may be referred to by different names. This document does not intend to distinguish between components that differ in name, but not function.

[0023] Referring now to the figures, FIG. 1 illustrates an implementation of a user interface of a mobile application 100 on a mobile device 102. As can be seen in the figure, the mobile device 102 may comprise a display 104 that is configured to digitally display information to a user. The mobile application 100 may be configured to convey bicycle space availability on a transit unit. For example, the mobile application 100 may show a public transit line schematic 110 having a plurality stations 115 marked on the schematic 110.

[0024] Additionally, the mobile application 100 may allow a user to select one of the plurality of stations 115 and receive bicycle space availability related to transit units at the selected station 115. As illustrated in the figure, the 22nd Street station 115a has been selected. The mobile application 100 may then retrieve bicycle space information from a bicycle space
server and display it on the display 104. In the present implementation, the mobile application 100 comprises and conveys a bicycle count 122, a transit unit graphic 124, and a numerical estimation 126 of availability.

[0025] FIG. 2 illustrates an alternative implementation of a user interface of a mobile application 200 on a mobile device 202. As can be seen in the figure, the mobile application 200 may be configured to convey bicycle space availability on a transit unit for a specified transit unit route between two stops. In the present embodiment, the mobile application 200 may allow a user to select a route between two stations 215a and 215b and receive bicycle space availability related to transit units between the stops. In the figure, the 22nd Street station 215a has been selected and the Palo Alto station 215b has been selected. The mobile application 200 may then retrieve bicycle space information from a bicycle space server (illustrated in FIG. 3) and display it on a display 204. In the present implementation, the mobile application 200 conveys a number of bicycle spaces remaining 222, a transit unit graphic 224, and a numerical estimation of riders queued to board and take bicycle spaces 228. In an implementation, the mobile application 200 may estimate the number of riders expected to use or take a bicycle space 228 at a particular transit stop. To accomplish this feature, the mobile application 200 may comprise a mechanism or module for users to "check-in" on the mobile application 200 and essentially reserve or otherwise take a bicycle space 228 at a particular transit stop. In an implementation, a user/rider may check-in and even schedule or reserve a particular time for a bicycle space 228. Similarly, the mobile application 200 allows a user/rider to "check-out" of a bicycle space 228 at a particular transit stop.

[0026] FIG. 3 illustrates a system 300 for determining bicycle space availability on a transit unit 302, wherein the transit unit 302 is a bicycle coach dedicated to both cyclists and their
bicycles 311. Accordingly, the transit unit 302 is part of a commuter train 301. In the present implementation, a user's mobile device 304 communicates both locally with a hub controller 306 through a mobile application running on the mobile device 304, and with a bicycle space server 321 over a network 319. It will be appreciated that the bicycle space server 321 may be located on the commuter train 301 and may be used to collect data from one or all of the transit units 302 that are part of that train 301. It will also be appreciated that the bicycle space server 321 may be located remotely with respect to the train 301 and may collect data for one or more transit units 302 that are part of a given commuter train 301 or that are part of different commuter trains 301. As can be seen in the figure, the transit unit 302 comprises a plurality of bicycle spaces 314, each of which has a corresponding sensor 303 for determining whether the space is occupied, wherein the sensor 303 is configured to generate occupancy status data and report the occupancy status data to the hub controller 306. In an implementation, the system 300 supports a real-time or on the fly approach, in which the transit unit 302 has one or more physical bicycle space sensors 303 on-board. The sensors 303 may communicate with the server 321 to identify whether a space is occupied or available. The mobile application running on the mobile device 304 may receive notifications when a space is occupied or available.

[0027] In the present implementation, the transit unit 302 comprises a threshold 323 to allow cyclists and their bicycles 311 ingress and egress. The threshold 323 may comprise one or more threshold sensors 305 that are configured to register the ingress and egress of cyclists and/or their bicycles 311. This may be done with digital tags, such as Radio Frequency Identification chips (RFID) or simple bar codes that comprise digital information therein that is read by the threshold sensors 305. Consistent with the use of threshold sensors 305, the mobile device 304 may also
be sensed by the threshold sensors 305 and result in the check-in status of the cyclist and bicycle
311 associated with the mobile device 304.

[0028] FIG. 4 shows a block diagram of a system 400 configured to determine the
availability of bicycle space on a public transit unit 402, according to an embodiment of the
present disclosure. As shown in FIG. 4, system 400 may include a sensor system 404, a bicycle
space availability hub controller 406, and a data storage device 408. System 400 interacts with
the hub controller 406 on the transit unit 402 to determine available bicycle space for each transit
unit 402. Transit unit 402 may include one or more bicycle space(s) 414, and may include any
configuration of the bicycle space(s) 414, including bicycle carriers on buses and trolleys, as well
as any other bicycle space configuration. The elements of system 400 shown in FIG. 4 are
described as follows. Sensor system 404 is configured to monitor bicycle space(s) 414 of transit
unit 402. Sensor system 404 may include one or more sensor elements to perform the
monitoring, including a sensor array. Sensor system 404 may include one or more of any
suitable type of sensor, including an optical sensor (e.g., a light emitter and photodetector, an
image capturing device such as a camera, etc.), an acoustic sensor, a proximity sensor, a
movement sensor, a weight sensor, a magnetic loop sensor, etc. Example sensors are described
in further detail below.

[0029] As shown in FIG. 4, sensor system 404 generates a sensor data output signal 410.
The hub controller 406 receives sensor data output signal 410 from the sensor system 404 and
generates bicycle space availability information 412. The hub controller 406 may be configured
to determine from sensor data output signal 410 that at least one bicycle space 414 is occupied.
The hub controller 406 may be configured to include an indication in the bicycle space
availability information 412 of the determined occupied bicycle spaces and an indication in the
bicycle space availability information 412 of unoccupied bicycle spaces, which may be indicated as available for bicycle docking. In an embodiment, the hub controller 406 may determine from the sensor data output signal 410 which of the bicycle spaces 414 are unoccupied, if any. Alternatively, the hub controller 406 may assume that bicycle spaces of the transit unit 402 that are not occupied may be indicated as available for docking bicycles therein.

[0030] In an embodiment, the hub controller 406 may generate bicycle space availability information 412 to include a list of all bicycle space(s) 414 in the transit unit 402 (e.g., listing each bicycle space by an associated identification number). Furthermore, the bicycle space availability information 412 may optionally include a graphic of the transit unit 402, with bicycle space availability overlaid on the graphic thereby indicating physical location information for each of the bicycle space(s) 414 in transit unit 402, and indicating which of bicycle space(s) 414 is occupied or available.

[0031] As shown in FIG. 5, bicycle space availability information 412 generated by hub controller 406 may be stored in data storage device 408. Data storage device 408 may include any type of storage mechanism, including a hard disk drive, an optical disc drive, a memory device such as a RAM device, a ROM device, etc., and/or any other suitable type of storage medium as discussed above.

[0032] In an embodiment, users may access bicycle space availability information 412 using electronic mobile devices to assist the users with selecting a transit unit. For instance, FIG. 5 shows a device 502 that accesses storage device 408 to receive bicycle space availability information 412 according to an example embodiment of the present disclosure. In an implementation, device 502 may directly access hub controller 406 for bicycle space availability information 412. Alternatively, device 502 may access storage 408 locally or over a network.
As shown in FIG. 5, device 502 includes a display 504. Display 504 enables display of bicycle space availability information 412 to a user of device 502. Display 504 of device 502 may display bicycle space availability information 412 to the user in a textual and/or graphical manner. For example, in an embodiment, bicycle space availability information 412 may be displayed by display 504 in a list that includes a listing of bicycle space identification numbers and availability information for transit unit 402.

Alternatively, in an embodiment, bicycle space availability information 412 may be graphically displayed by display 504 in the form of an overhead view of bicycle spaces on the transit unit 402, graphically showing each of the bicycle spaces 414 as available or occupied. As seen in the figure, a bicycle space availability image 550 may be generated from bicycle space availability information 412, and displayed by display 504 of device 502, according to an example embodiment of the present disclosure. As shown in FIG. 5, bicycle space availability image 550 is an image of a transit unit 402. In the example of FIG. 5, bicycle space transit unit 402 includes a row of bicycle spaces 414. Each displayed bicycle space 414 may optionally include an identification number, and the graphic image 550 may further display an available bicycle space 414 as empty, and displays an occupied bicycle space 414 as including a bicycle icon. In other embodiments, available 414a and occupied 414b bicycle spaces 414 may be indicated in alternative ways. A user of device 502 that desires to dock a bicycle in transit unit 402 may refer to the graphical display (which also optionally includes textual information) by display 504 of image 550, which shows an arrangement of bicycle spaces 414 and availability information.

Communications between system 400 of FIG. 4 and device 502 of FIG. 5 may be performed in a variety of ways. For instance, FIG. 6 shows a block diagram of a bicycle space
availability check-in system 600, according to an embodiment of the present disclosure. As shown in FIG. 6, system 600 includes the components of system 400 and further comprises a network 604, a bicycle space server 606, and devices 602a, 602b, and 602c. As shown in FIG. 6, the system 400 includes the sensor system 404, the hub controller 406, and storage device 408. In the embodiment of FIG. 6, the hub controller 406 includes a communication interface 614. The hub controller 406 is communicatively coupled with devices 602a, 602b, and 602c through network 604. It will be appreciated that network 604 may be a LAN, a WAN, or combination of networks, such as the Internet. In FIG. 6, three example devices are shown as devices 602a, 602b, and 602c for purposes of illustration and simplicity of discussion only. However, it will be appreciated that hundreds, thousands, or even millions of devices may be present, such as devices 602a, 602b, and 602c. Example devices 602a, 602b, and 602c are, respectively, a desktop computer 608, a mobile computing device 610, and a mobile phone 612. Mobile computing device 610 may be any type of mobile computing device, including a mobile computer (e.g., a personal digital assistant (PDA), a laptop computer, a notebook computer, smart phone, etc.). It will be appreciated that any number of devices 502 or any type of device capable of interacting with hub controller 406 may be used by the users of the present disclosure to interact with the hub controller 406 to obtain bicycle space availability information 412. Mobile devices, such as mobile phone 612, may be particularly useful for obtaining and displaying substantially real time bicycle space availability information 412, such as when the user of the mobile device is nearing or has entered a transit unit 402.

[0035] Each user device 602a, 602b, and 602c may communicate with the hub controller 406 through a corresponding communication link to determine bicycle space availability. For example, as shown in FIG. 6, desktop computer 608 is communicatively coupled with network
604 through a first communication interface 618; mobile computing device 610 is communicatively coupled with network 604 through a second communication interface 620; and mobile phone 612 is communicatively coupled with network 604 through a third communication interface 622. The hub controller 406 is shown as being communicatively coupled with network 604 through a fourth communication interface 614. The first through fourth communication interfaces 618, 620, 622, and 614, respectively, may include any type or combination of communication links, including wired and/or wireless links, such as IEEE 802.11 wireless LAN (WLAN) wireless links, cellular network links, wireless personal area network (PAN) links (e.g., Bluetooth links), etc. Techniques such as webpage browsing, emailing, text messaging (e.g., SMS—short message service), etc., may be used to provide bicycle space availability information 412 to desktop computer 608, mobile computing device 610, and mobile phone 612 over communication interfaces 618, 620, and 622, respectively. Communication interface 614 may be configured to enable communications by the hub controller 406 over network 604 to various user devices, such as devices 602a, 602b, and 602c.

[0036] In an embodiment, the bicycle space server 606 may be present in the system 600. The bicycle space server 606 may be a bicycle space tracking server that may be used to generate bicycle space availability information. According to an embodiment, bicycle space server 606 may be configured to generate bicycle space availability information for display on a device, such as 602a, 602b, or 602c. For example, in an embodiment, a user may enter a start location (e.g., in the form of an address, a city, a zip code, etc.) and a destination location into an interface (e.g., a web browser) at a device, such as 602a, 602b, or 602c. Alternatively, the user may enter just a destination location, or may enter a specific transit unit. A device, such as 602a, 602b, or 602c, transmits the entered location information in a communication signal over a
communication interface, such as 618, 620, or 622, through the network 604 to bicycle space server 606 (which may be hosted by one or more servers) over a communication interface 605. Bicycle space server 606 receives and processes the location information into bicycle space data, which may include mapping information regarding the start and destination locations, information for public transportation from the start location to the destination location, and/or bicycle space availability information 412. For example, a transit unit, such as bicycle space transit unit 402, is present within the bicycle space information 412 that is to be generated by bicycle space server 606. The bicycle space server 606 may transmit a communication signal over the communication interface 605 through network 604 to hub controller 406 to request bicycle space availability information 412 for transit unit 402. The hub controller 406 may generate bicycle space availability information 412 for the transit unit 402 in response to the request, or may access bicycle space availability information 412 in storage 408 that was already generated for the transit unit 402.

[0037] The hub controller 406 may transmit the generated/accessed bicycle space availability information 412 in a communication signal through network 604 to bicycle space server 606. Bicycle space server 606 incorporates the received bicycle space availability information 412 into the bicycle space data generated in response to the request by device 602, and transmits the bicycle space data in a communication signal through network 604 to the requesting device 602. The display of the receiving mobile device 602 displays the bicycle space information.

Furthermore, bicycle space information may be coded to indicate various levels of bicycle space availability indicated by bicycle space availability information 412. For example, bicycle space server 606 may use colors and/or patterns to indicate a level of bicycle space availability for bicycle space in the transit unit 402. For instance, bicycle space transit unit 402 may be
colored/tinted green to indicate a relatively high number of available bicycle spaces, or may be colored/tinted red to indicate a relatively low number of available bicycle spaces.

[0038] Referring now to FIG. 7, system 400 (shown in FIG. 4) may be configured to generate bicycle space availability information 412 in various ways, including various methods described throughout this disclosure. Illustrated in FIG. 7 is a flowchart 700 for generating bicycle space availability information, according to an implementation of the present disclosure. Further, structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart 700.

[0039] Flowchart 700 begins with step 702. At 702, a plurality of bicycle spaces on a transit unit 402 are monitored for occupancy status. In an embodiment, sensor system 404 may monitor bicycle space(s) 414 of the transit unit 402. For example, a sensor array may include a plurality of sensor elements with each sensor element being associated with one or more bicycle spaces 414, or with multiple sensor elements being associated with each bicycle space 414.

[0040] At 704, the sensor system 404 generates an output signal 410 comprising its occupancy status and corresponding occupancy status data. The occupancy status data is transmitted to the hub controller 406. The sensor data output signal 410 includes sensor data generated by one or more sensor elements of sensor system 404. The hub controller 406 is configured to analyze the sensor data to determine whether bicycle space(s) 414 of transit unit 402 are occupied or available.

[0041] At 706, bicycle space availability information is generated by the hub controller 406 that includes an indication of bicycle space occupancy status within a transit unit 402. As described above, bicycle space availability hub controller 406 generates bicycle space availability information 412, which includes an indication of which of bicycle space(s) 414 are
occupied and which are available for docking a bicycle. As described above, in an embodiment, any of bicycle space(s) 414 that are not determined to be occupied at 706 may be indicated as unoccupied, and thus may be indicated as available for docking or parking.

[0042] At 708, the bicycle space availability information is packaged. The packaged space availability information may correspond to a specific space sensor, thereby identifying the status of that specific bicycle space 414 within the transit unit 402. The packaged space availability information may be provided for each bicycle space 414 within the transit unit 402.

[0043] At 710, the hub controller 406 transmits the packaged space availability information to a bicycle space server 606 over a network 604 (see also FIG. 6).

[0044] At 712, the bicycle space server 606 generates a graphic representing the transit unit 402 and bicycle space availability on the transit unit 402. At 714, the bicycle space server 606 transmits space availability information to a user's mobile device 602 (see also FIG. 6).

[0045] At 716, the bicycle space server 606 receives check-in information from a mobile application running on a user's mobile device (see also FIGS. 1 and 2). It should be noted that in an implementation of the mobile application may generate check-in data automatically, or alternatively the user may cause the mobile application to generate check-in data.

[0046] At 718, the bicycle space server 606 may generate projected or probable occupancy level data for transmitting to mobile application users.

[0047] At 720, the mobile application may facilitate direct communication between the hub controller 406 and users' mobile devices 602. In such an implementation, a user could communicate with a plurality of hub controllers 406 corresponding to a plurality of transit units 402, for example, to find a transit unit 402 or bicycle coach that is part of a vehicle, such as a train, that has space available for docking or parking a bicycle.
At 722, the bicycle space sensor system 404 automatically detects a digital tag affixed to a bicycle with one or more sensors as the bicycle is positioned within the bicycle space 414. Additionally, a digital tag may trigger sensors 305 at the thresholds 323 of transit units (see also FIG. 3). In such an embodiment, the system may report an occupancy count within a transit unit, but not an exact bicycle space occupancy location.

Example embodiments for a sensor system 404 will now be described. As noted above, the sensor system 404 may include a single sensor element, or a plurality of sensor elements, such as an array of sensors. In an example embodiment, the sensor system may include one or more first sensor elements and corresponding one or more second sensor elements. The first sensor element may be positioned in the bicycle space, such that the first sensor elements are located at one end of the space with the corresponding second sensor elements being located opposite the first sensor elements within the space. Each of the corresponding sensor elements may comprise a light emitter and a light detector. Each light sensor element emits a light beam directed to the corresponding light detector. Each light beam is directed across a corresponding bicycle space such that if a bicycle enters the corresponding bicycle space, the light beam will be blocked from being received by the corresponding light detector. An indication of whether the light beam is or is not received by the corresponding light detector is provided in a sensor element output signal for each of the sensor elements. Each sensor element output signal may be received by the hub controller to determine whether a corresponding one of the bicycle spaces is occupied or available.

In an example embodiment, sensor elements may be mechanical sensors, such as contact or touch sensors, etc. Sensor elements may be respectively positioned in bicycle spaces with each sensor element positioned in a respective bicycle space, such that if a bicycle enters
the bicycle space the sensor element is moved or displaced by the vehicle. For example, a sensor element may include one or more levers that extend into a bicycle space. Alternatively, the sensor element may be a spring-loaded object that extends from a back end of a bicycle space towards the center of the bicycle space. It will be appreciated that other suitable mechanical sensor configurations may also be utilized by the present disclosure without departing from the scope of the disclosure. An indication of whether sensor element is moved or displaced is provided in a sensor element output signal for each of the sensor elements. Each sensor element output signal is received by the hub controller to determine whether each of the bicycle spaces is occupied or available.

[0051] In an example embodiment, sensor elements may be weight sensors, such as strain gauges, scales, etc. In the example, the sensor elements are positioned in bicycle spaces with each sensor element positioned in a respective bicycle space, such that if a vehicle enters the bicycle space the weight of the vehicle causes an output of the sensor element to change. For example, sensor elements may be located in or on a floor of bicycle spaces of the transit units. A sensor element may be configured to determine whether a weight present in a corresponding bicycle space is under a predetermined threshold weight. If the predetermined threshold weight is not met, a bicycle and/or a bicycle rider are assumed to not be present in the bicycle space. If the predetermined threshold is exceeded, then a bicycle and/or bicycle rider are assumed to be present in a bicycle space.

[0052] It should be noted that the sensor embodiments discussed above may comprise computer hardware, software, firmware, or any combination thereof to perform at least a portion of their functions. For example, a sensor may include computer code configured to be executed in one or more processors, and may include hardware logic/electrical circuitry controlled by the
computer code. These example devices are provided herein purposes of illustration, and are not intended to be limiting. Embodiments of the present disclosure may be implemented in further types of devices, as would be known to persons skilled in the relevant art(s).

[0053] Embodiments of the disclosure have been directed to computer program products comprising such logic (e.g., in the form of software) stored on any computer useable medium. Such software, when executed in one or more data processing devices, causes a device to operate as described herein.

[0054] While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the disclosure. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents. The foregoing description has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. Further, it should be noted that any or all of the aforementioned alternate implementations may be used in any combination desired to form additional hybrid implementations of the disclosure.

[0055] Further, although specific implementations of the disclosure have been described and illustrated, the disclosure is not to be limited to the specific forms or arrangements of parts so described and illustrated. The scope of the disclosure is to be defined by the claims appended hereto, any future claims submitted here and in different applications, and their equivalents.
CLAIMS

1. A system for determining availability of bicycle space on public transit units, comprising:
   a plurality of space sensors, each space sensor configured to monitor occupancy of a bicycle space and generate a data output signal indicating occupancy status; and
   a hub controller configured to receive the data output signal from each of the plurality of space sensors, generate bicycle space information for a transit unit, and communicate the bicycle space information to a server.

2. The system of claim 1, further comprising a website that reports the bicycle space information to users.

3. The system of claim 1, further comprising a mobile application that is configured to run on a mobile electronic device and communicate over a network with the hub controller in order to convey the bicycle space information to users.

4. The system of claim 3, wherein the mobile application is configured to receive bicycle space check-in information from a user directly on the mobile electronic device.

5. The system of claim 3, wherein the mobile application is configured to automatically report bicycle space check-in information based on a user's position within the transit unit.
6. The system of claim 3, wherein the mobile application is configured to facilitate direct communication between the mobile electronic device and the hub controller.

7. The system of claim 1, further comprising a digital information tag configured to be attached to a bicycle and read by the hub controller.

8. The system of claim 1, wherein the hub controller corresponds to a specific transit unit and monitors bicycle spaces therein.

9. The system of claim 3, further comprising a transit unit graphic that graphically shows bicycle space availability for the transit unit.

10. The system of claim 3, wherein the mobile application reports probable bicycle space availability on future transit units.

11. A method for determining availability of bicycle space on public transit units, comprising:

   monitoring a plurality of space sensors, each space sensor being configured to monitor occupancy of a bicycle space and generate a data output signal indicating occupancy status;

   receiving the data output signal from each of the plurality of space sensors at a hub controller;

   generating bicycle space information for a transit unit at the hub controller; and
digitally communicating the bicycle space information to a server.
12. The method of claim 11, further comprising receiving bicycle space check-in information from a user directly on a mobile electronic device.

13. The method of claim 11, further comprising automatically reporting bicycle space check-in information based on a user's position within the transit unit.

14. The method of claim 11, further comprising receiving a direct communication from the hub controller through a mobile electronic device.

15. The method of claim 11, further comprising monitoring for one or more digital information tags that are configured to be attached to a bicycle.

16. The method of claim 15, further comprising receiving digital tag information.

17. The method of claim 11, further comprising monitoring a plurality of bicycle spaces with the hub controller that corresponds to a specific transit unit.

18. The method of claim 17, further comprising generating a graphical representation of the transit unit.

19. The method of claim 11, further comprising generating space availability information for future transit units.
20. The method of claim 11, further comprising generating a probability of bicycle space availability.
FIG. 5
Monitoring A Plurality Of Bicycle Spaces For Occupancy Status

Generating An Output Signal Comprising Occupancy Status Data Obtained From Sensors And Transmitting The Data To The Hub Controller

Generating Bicycle Space Availability Information At The Hub Controller Indicating Bicycle Space Occupancy Status Within A Transit Unit

Packaging Bicycle Space Availability Information So As To Correspond To A Specific Space Sensor

Transmitting The Packaged Space Availability Information From The Hub Controller To A Bicycle Space Server Over A Network

Generating A Graphic Representing The Transit Unit And Bicycle Space Availability On The Transit Unit At The Bicycle Space Server

Transmitting The Space Availability Information From The Bicycle Space Server To A User's Mobile Device

Receiving Check-in Information At The Bicycle Space Server From A Mobile Application Running On A User's Mobile Device

Generating Projected Or Probable Occupancy Level Data By The Bicycle Space Server For Transmitting To Mobile Application Users

Facilitating Direct Communication Between The Controller Hub And Users' Mobile Devices Using The Mobile Application

Automatically Detecting A Digital Tag Affixed To A Bicycle With Bicycle Space Sensors As The Bicycle Is Positioned Within The Bicycle Space

FIG. 7
### INTERNATIONAL SEARCH REPORT

**International application No.**
PCT/US 15/44090

#### A. CLASSIFICATION OF SUBJECT MATTER

<table>
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<tr>
<th>IPC(8)</th>
<th>CPC</th>
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According to International Patent Classification (IPC) or to both national classification and IPC

#### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data), Google Scholar, IEEE, ProQuest; Search Terms: bicycle, bike, transit, transportation, communicat*, availabP, space, rack

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>US 7783530 B2 (SLEMMER, J, ET AL), 24 August 2010; figure 1B and 5, claim 9, paragraph [0036], [0048], [0059], [0073], [0075], [0086], and [0087]</td>
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<td>Y</td>
<td>US 2013/0041941 A1 (TOMASIC, A, ET AL), 14 February 2013, paragraph [0028], [0029], [0032], [0033], [0045] - [0047], and [0064]</td>
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☐ Further documents are listed in the continuation of Box C.  
☐ See patent family annex.

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Date of the actual completion of the international search:

06 October 2015 (06.10.2015)

Date of mailing of the international search report:

09 Nov 2015

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

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