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(54) **SYSTEM AND METHODS FOR LOCATION VERIFICATION WITH BLOCKCHAIN CONTROLS**

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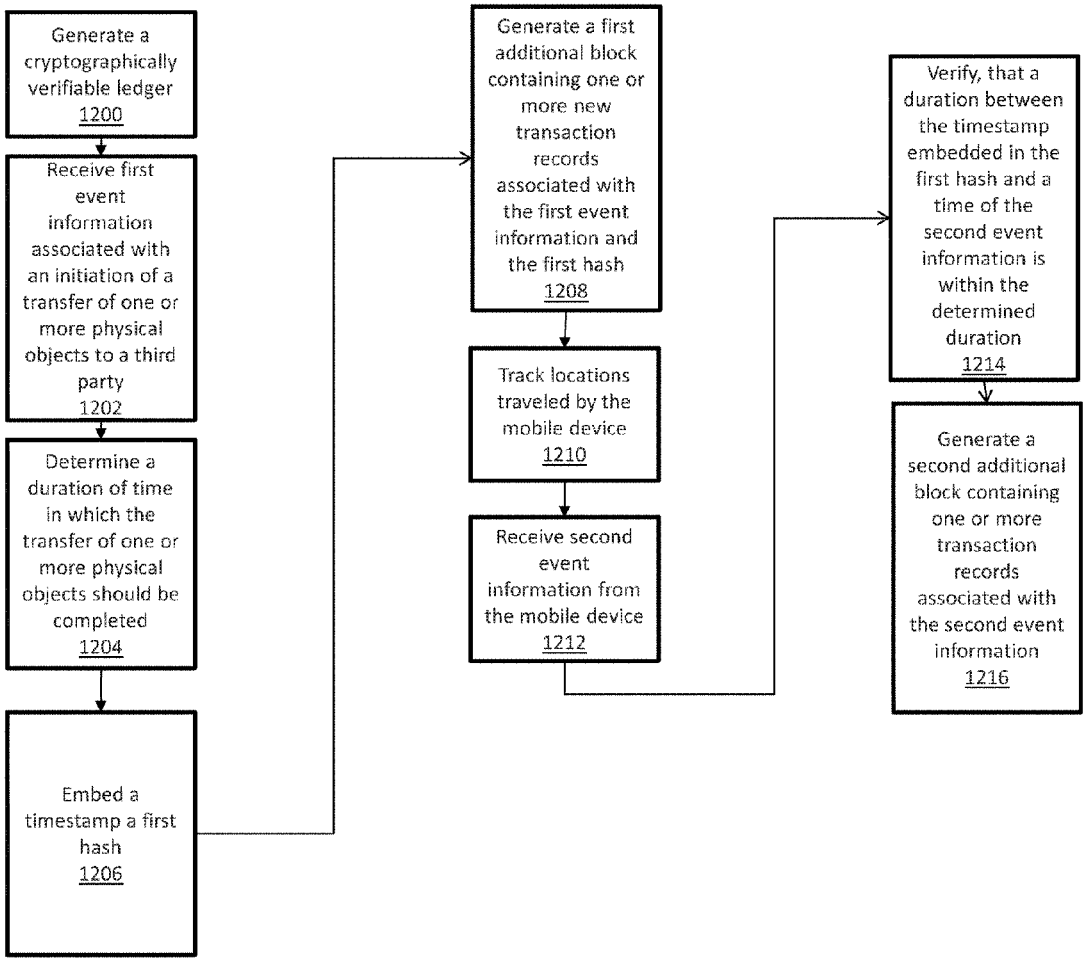
(57) **ABSTRACT**

Described in detail herein is a location verification system that includes a central computing system can generate a cryptographically verifiable ledger. The central computing system can receive first event information associated with an initiation of a transfer of one or more physical objects to a third party. In response to receiving the first event information the central computing system can generate in the cryptographically verifiable ledger additional block information associated with the first event information and a first hash. The central computing system can verify that the locations traveled by the mobile device correspond with a path embedded in the first hash and can generate a second additional block containing one or more transaction records associated with the second event information in response to the verification.



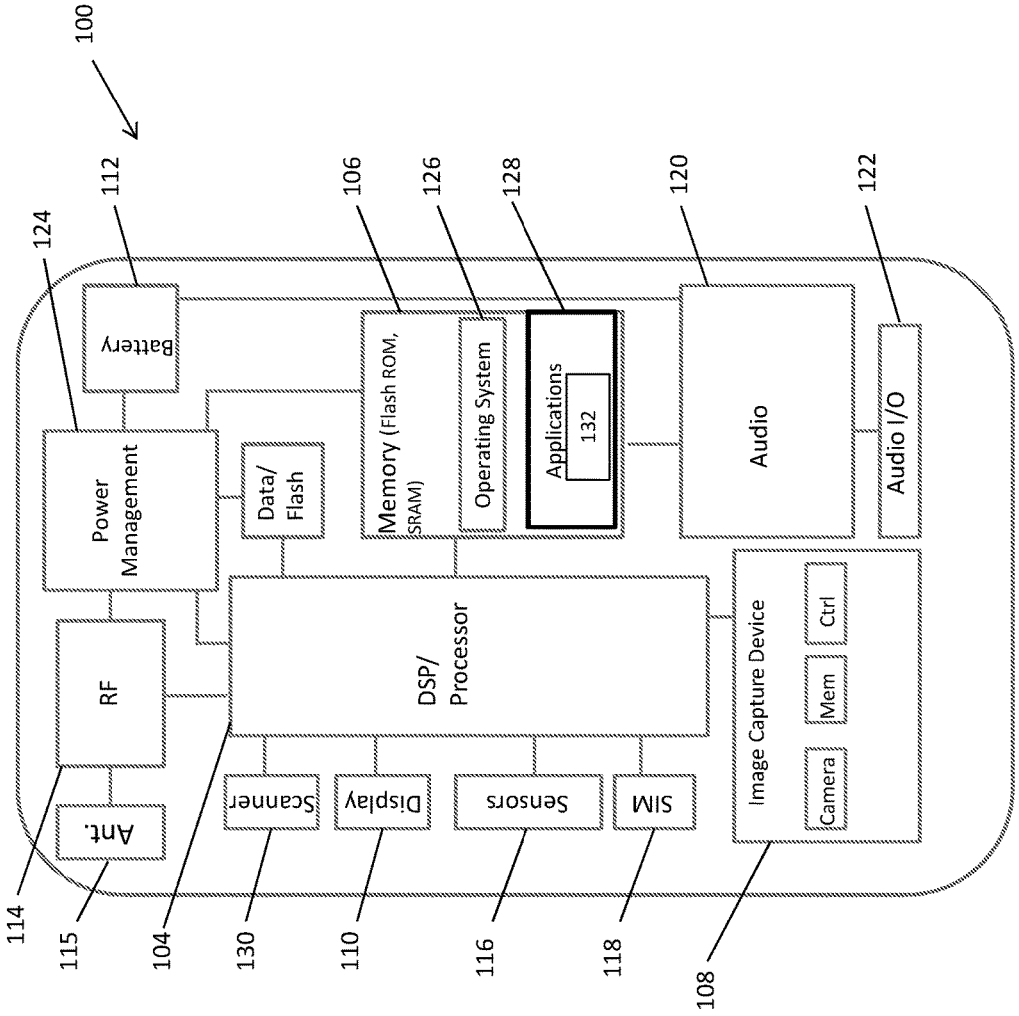

100
112
124
106
126
128
120
122
Battery
Power Management
Data/ Flash
Memory (Flash ROM, SRAM)
Operating System
Applications
132
Audio
Audio I/O
RF
DSP/ Processor
Image Capture Device
Ctrl
Mem
Camera
Ant.
Scanner
Display
Sensors
SIM
114
115
104
130
110
116
118
108

FIG. 1

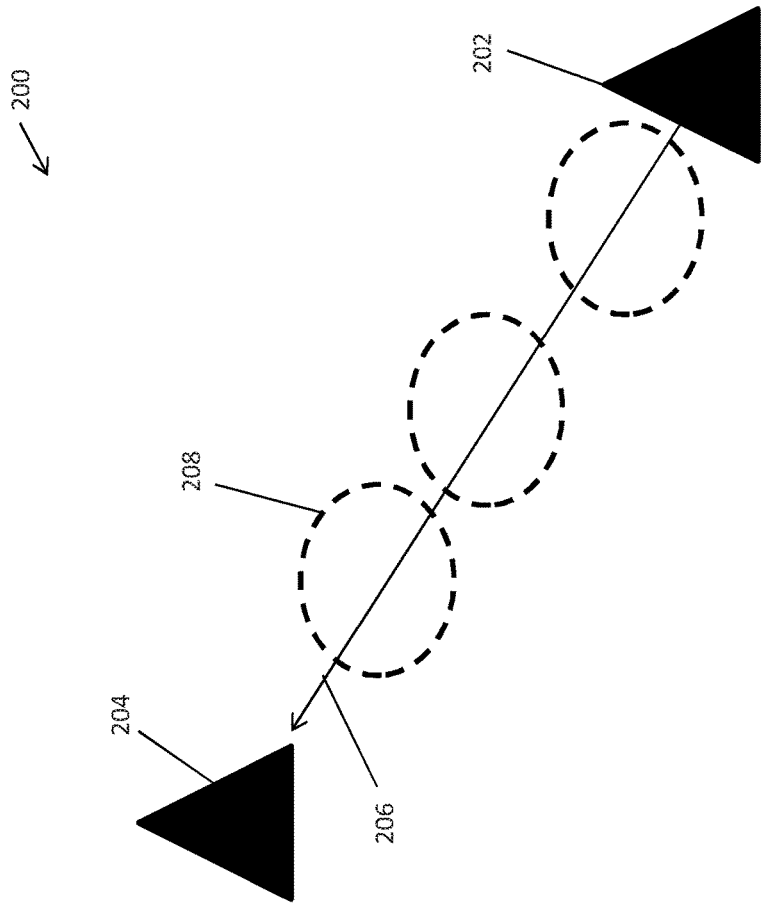


FIG. 2

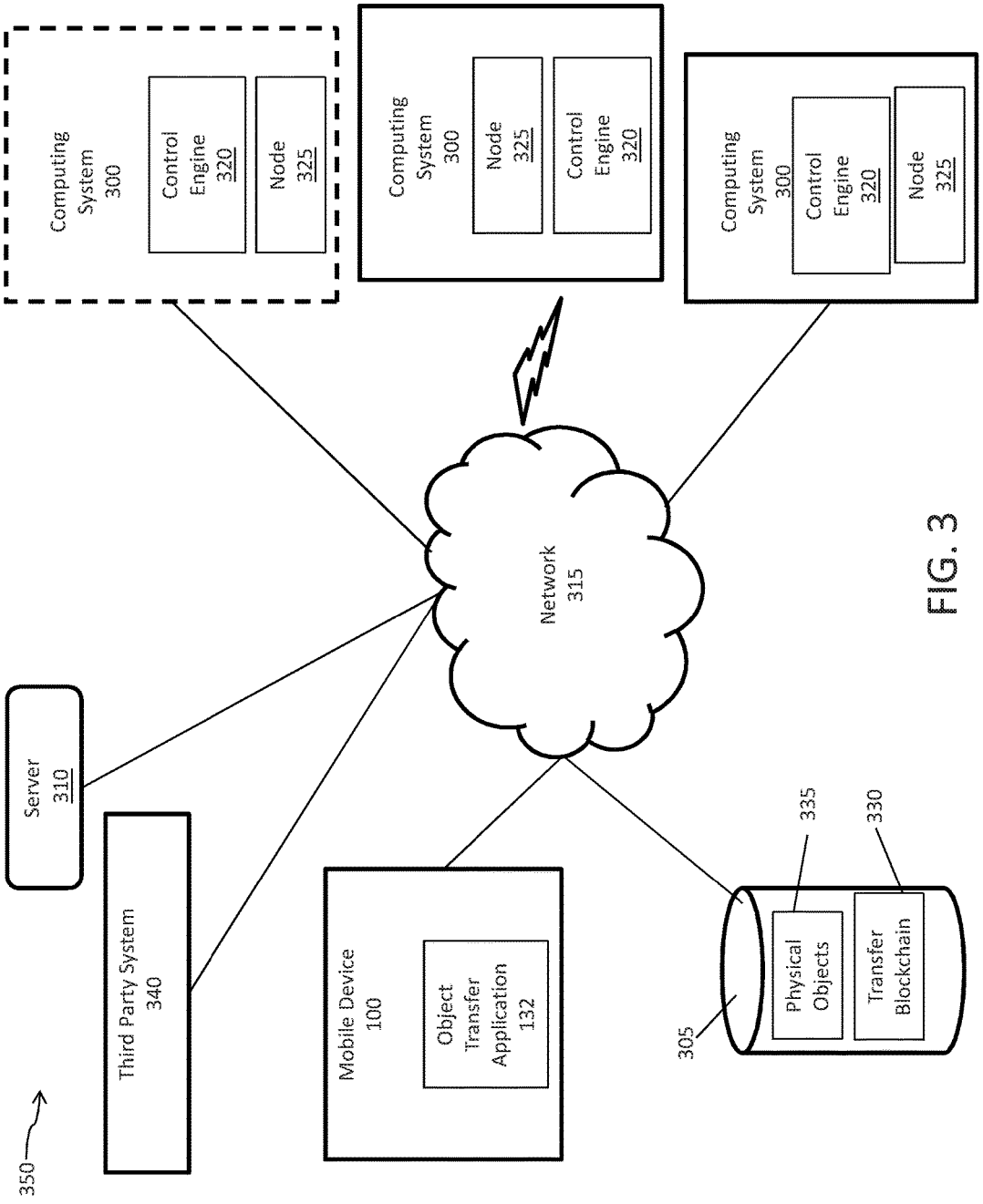

Computing System 300
Control Engine 320
Node 325
Computing System 300
Node 325
Control Engine 320
Computing System 300
Control Engine 320
Node 325
Network 315
Server 310
Third Party System 340
Mobile Device 100
Object Transfer Application 132
305
335
Physical Objects
330
Transfer Blockchain
350

FIG. 3

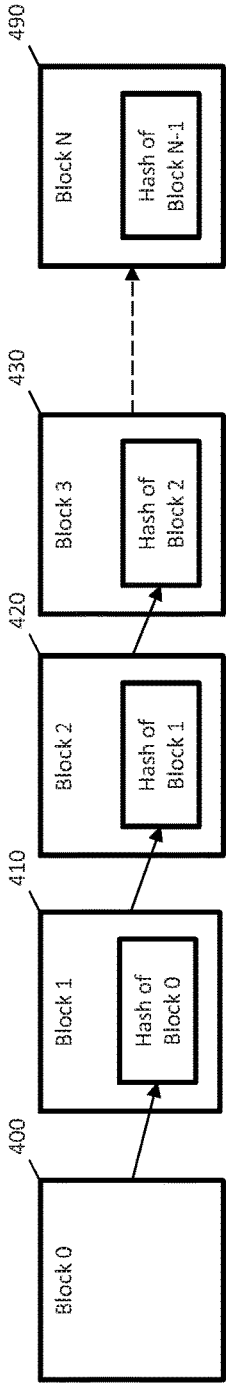

400
Block 0
410
Block 1
Hash of Block 0
420
Block 2
Hash of Block 1
430
Block 3
Hash of Block 2
490
Block N
Hash of Block N-1

FIG. 4

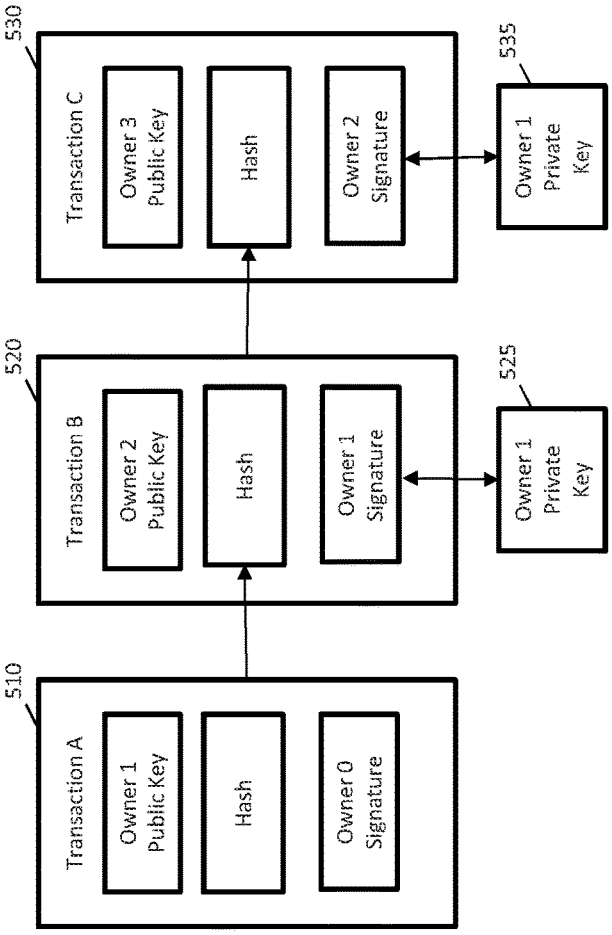

510
Transaction A
Owner 1 Public Key
Hash
Owner 0 Signature
520
Transaction B
Owner 2 Public Key
Hash
Owner 1 Signature
525
Owner 1 Private Key
530
Transaction C
Owner 3 Public Key
Hash
Owner 2 Signature
535
Owner 1 Private Key

FIG. 5

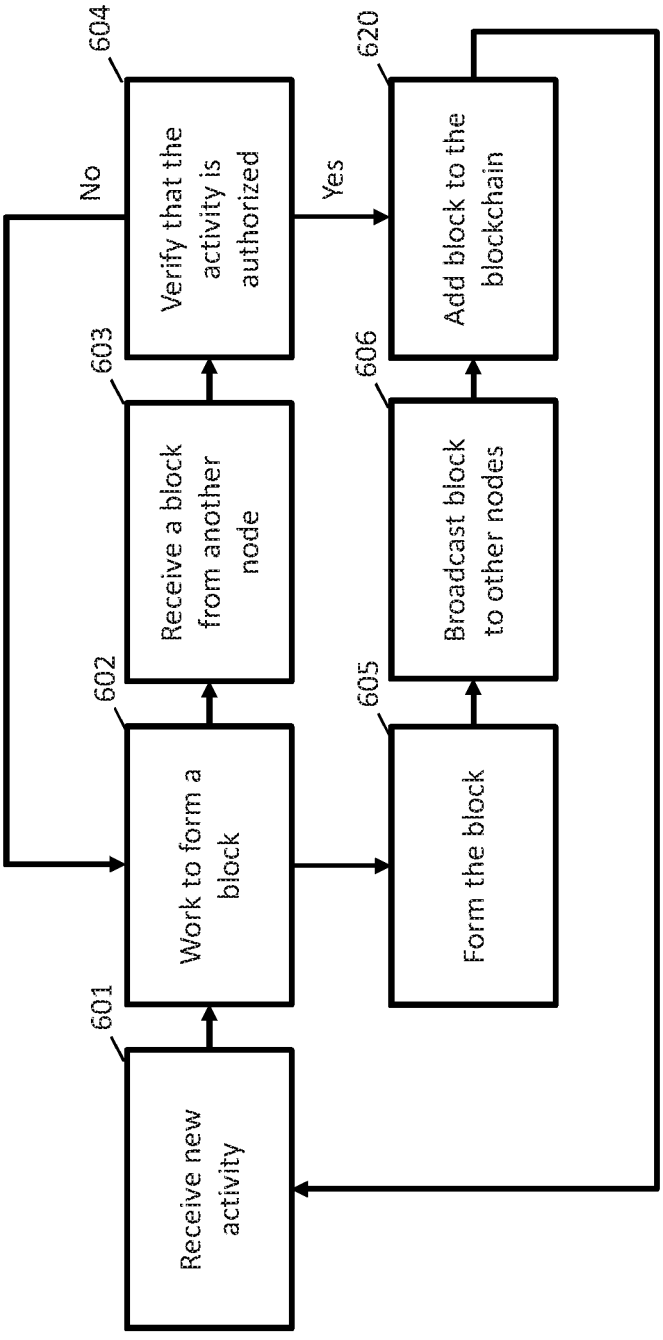

601
Receive new activity
602
Work to form a block
603
Receive a block from another node
604
Verify that the activity is authorized
No
Yes
605
Form the block
606
Broadcast block to other nodes
620
Add block to the blockchain

FIG. 6

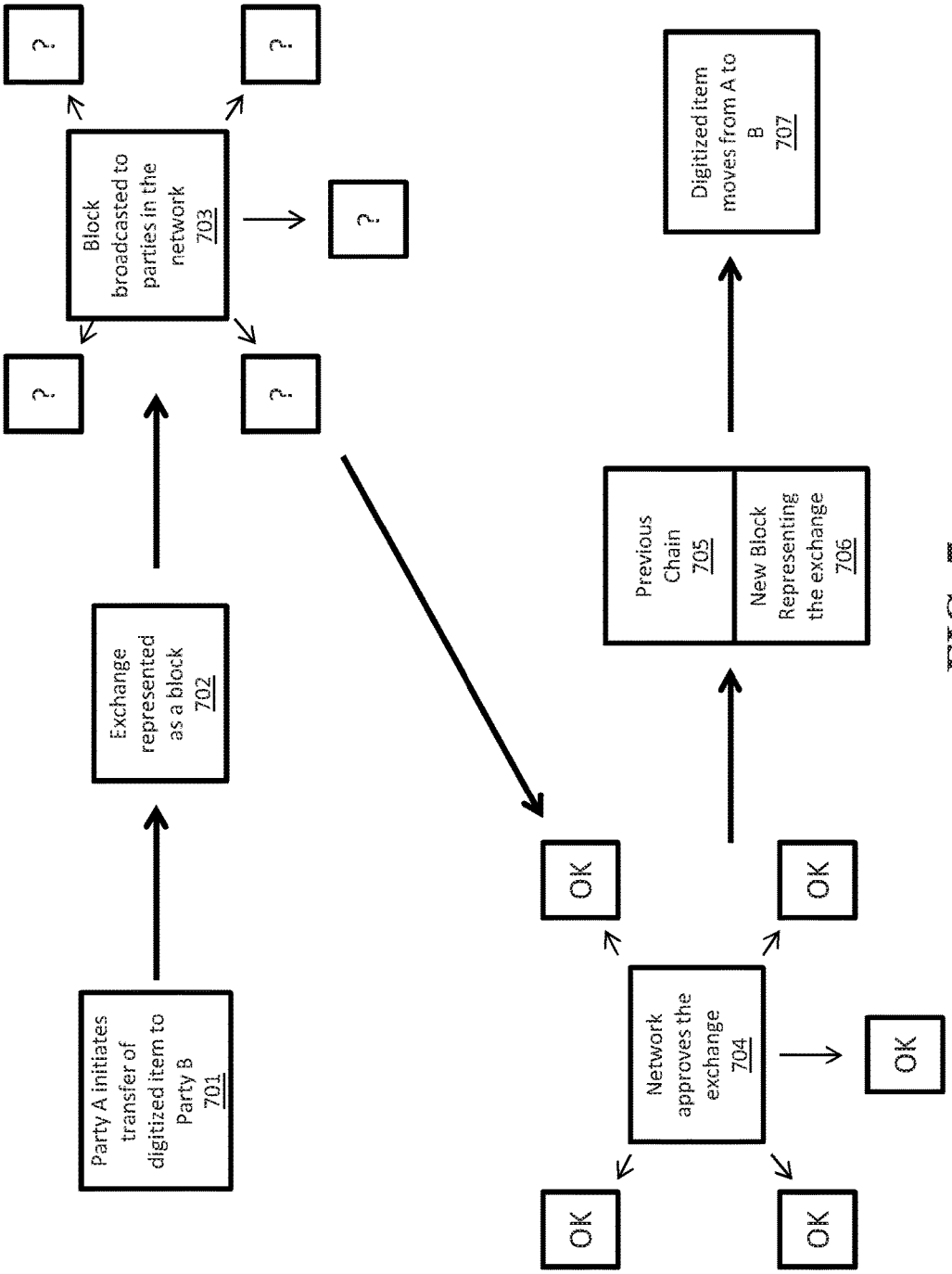

Party A initiates transfer of digitized item to Party B 701
Exchange represented as a block 702
Block broadcasted to parties in the network 703
?
?
?
?
?
Network approves the exchange 704
OK
OK
OK
OK
OK
Previous Chain 705
New Block Representing the exchange 706
Digitized item moves from A to B 707

FIG. 7

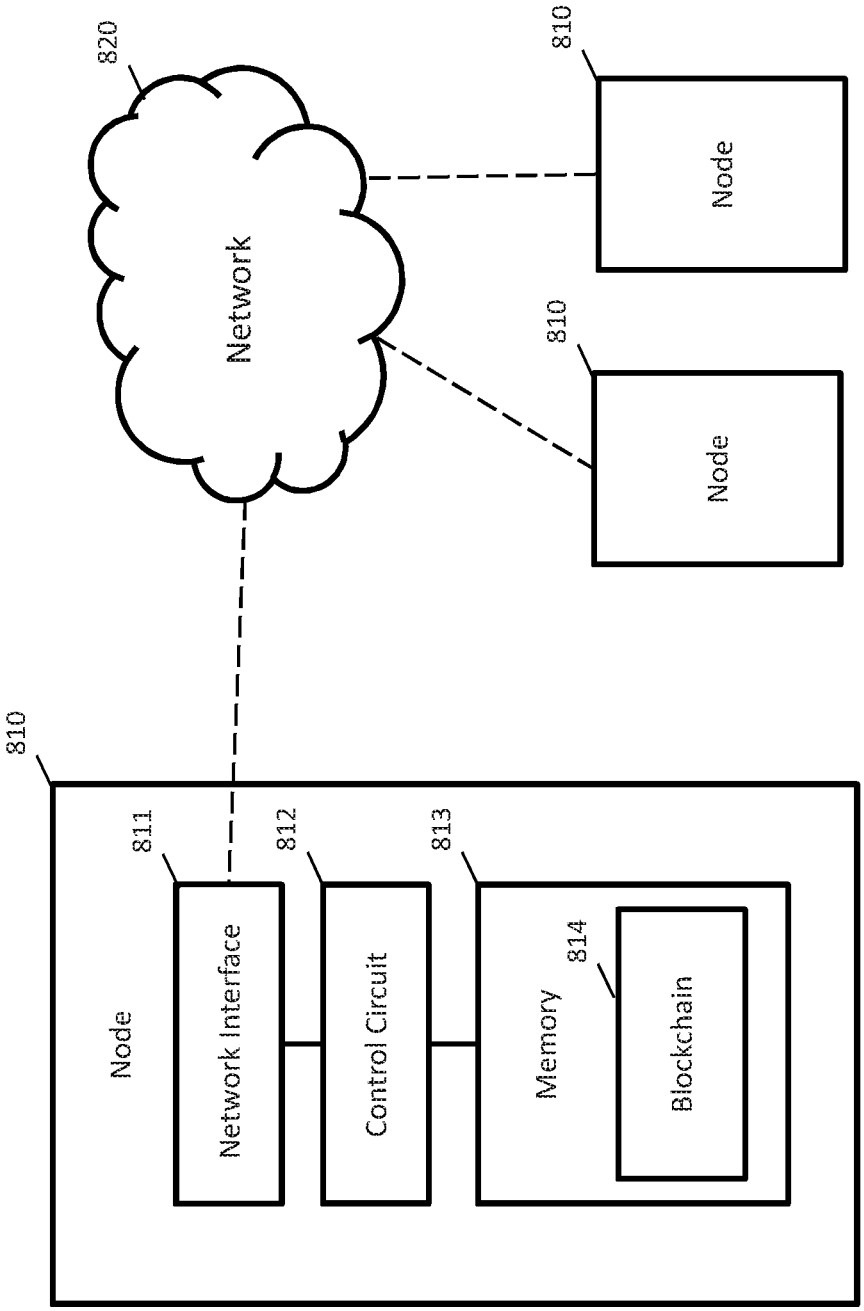

820
Network
810
Node
810
Node
810
Node
811
Network Interface
812
Control Circuit
813
Memory
814
Blockchain

FIG. 8

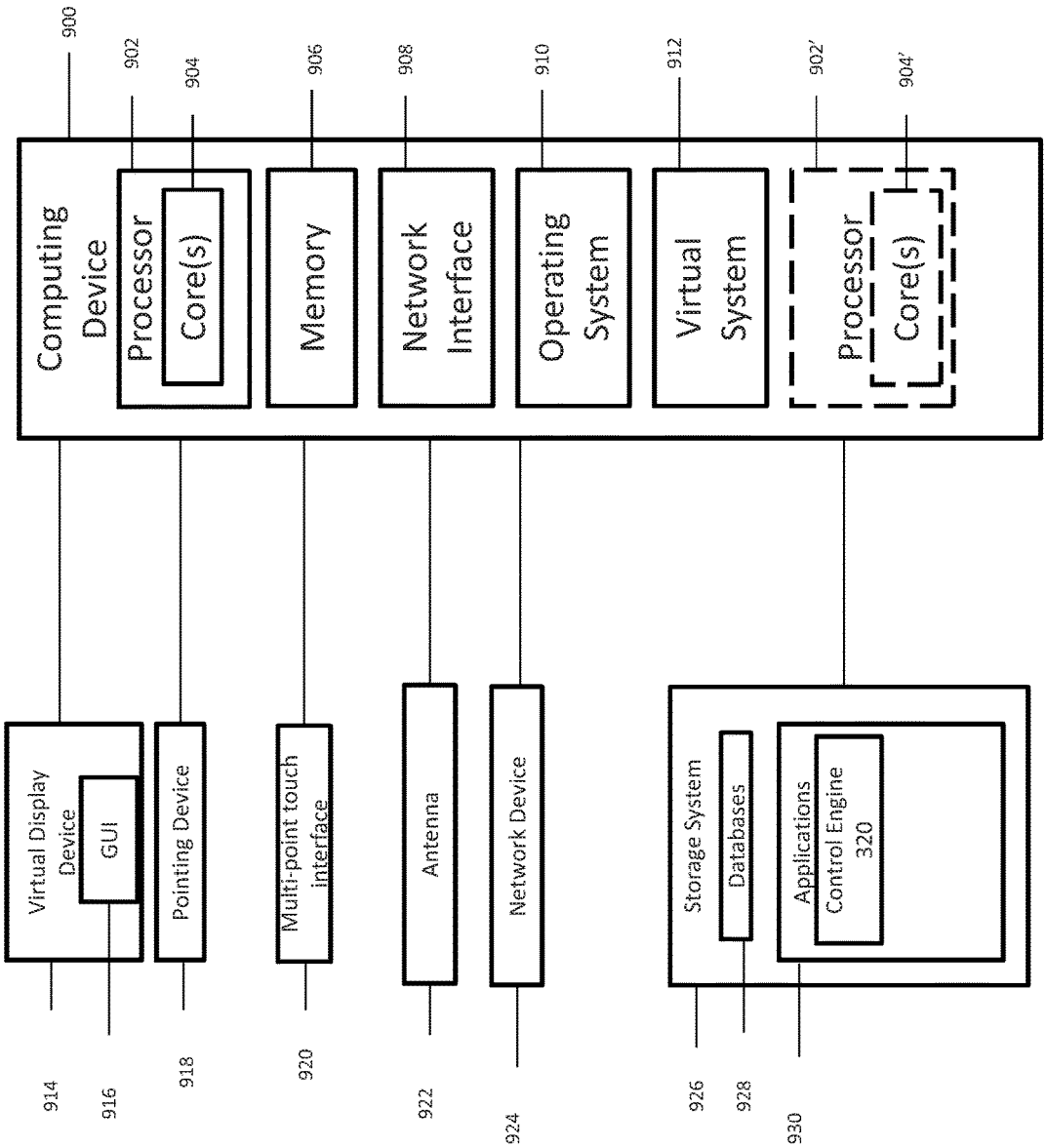

900
902
904
906
908
910
912
902'
904'
Computing Device
Processor
Core(s)
Memory
Network Interface
Operating System
Virtual System
Processor
Core(s)
Virtual Display Device
GUI
Pointing Device
Multi-point touch interface
Antenna
Network Device
Storage System
Databases
Applications
Control Engine
320
914
916
918
920
922
924
926
928
930

FIG. 9

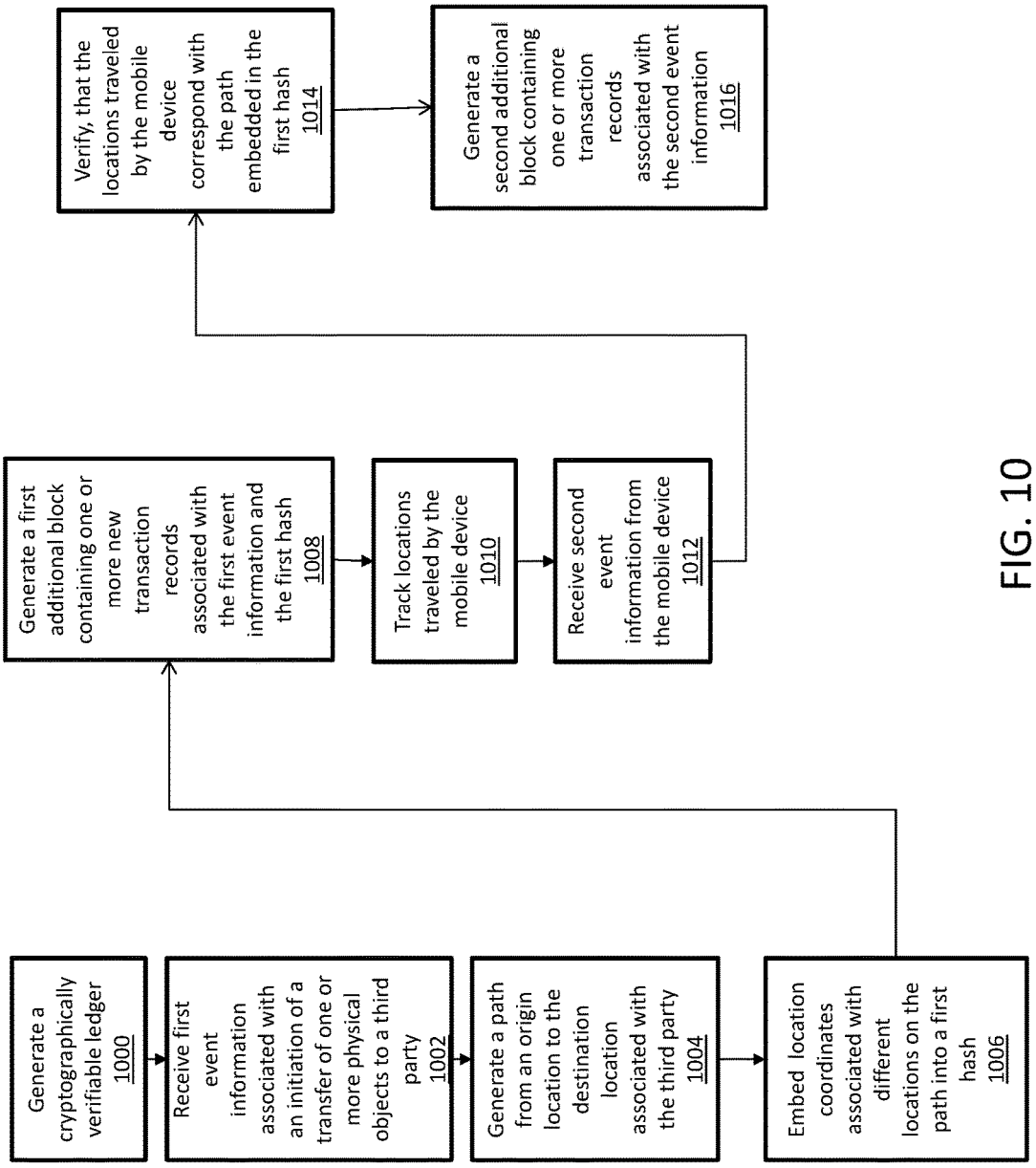

Generate a cryptographically verifiable ledger 1000
Receive first event information associated with an initiation of a transfer of one or more physical objects to a third party 1002
Generate a path from an origin location to the destination location associated with the third party 1004
Embed location coordinates associated with different locations on the path into a first hash 1006
Generate a first additional block containing one or more new transaction records associated with the first event information and the first hash 1008
Track locations traveled by the mobile device 1010
Receive second event information from the mobile device 1012
Verify, that the locations traveled by the mobile device correspond with the path embedded in the first hash 1014
Generate a second additional block containing one or more transaction records associated with the second event information 1016

FIG. 10

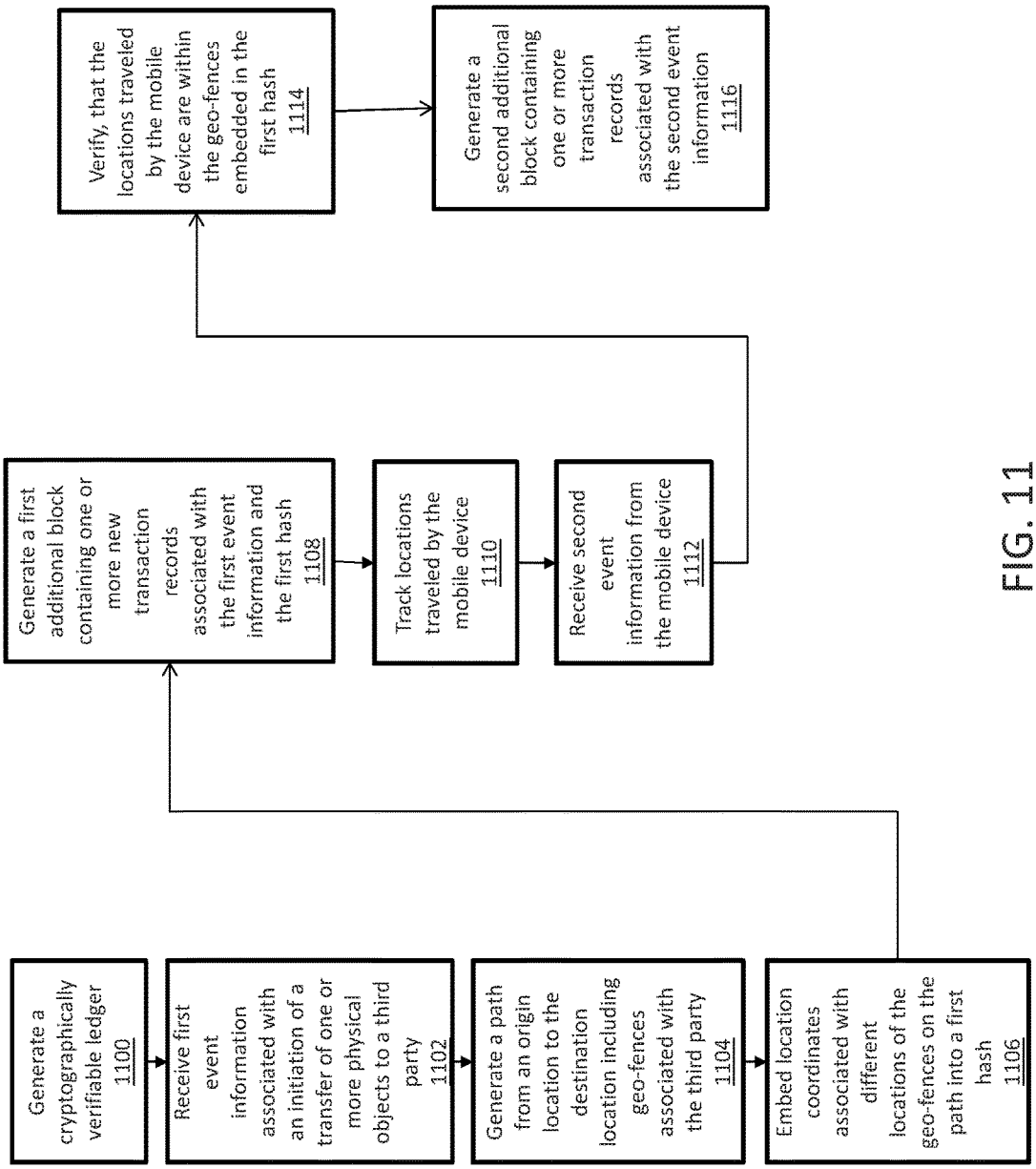

Generate a cryptographically verifiable ledger 1100
Receive first event information associated with an initiation of a transfer of one or more physical objects to a third party 1102
Generate a path from an origin location to the destination location including geo-fences associated with the third party 1104
Embed location coordinates associated with different locations of the geo-fences on the path into a first hash 1106
Generate a first additional block containing one or more new transaction records associated with the first event information and the first hash 1108
Track locations traveled by the mobile device 1110
Receive second event information from the mobile device 1112
Verify, that the locations traveled by the mobile device are within the geo-fences embedded in the first hash 1114
Generate a second additional block containing one or more transaction records associated with the second event information 1116

FIG. 11

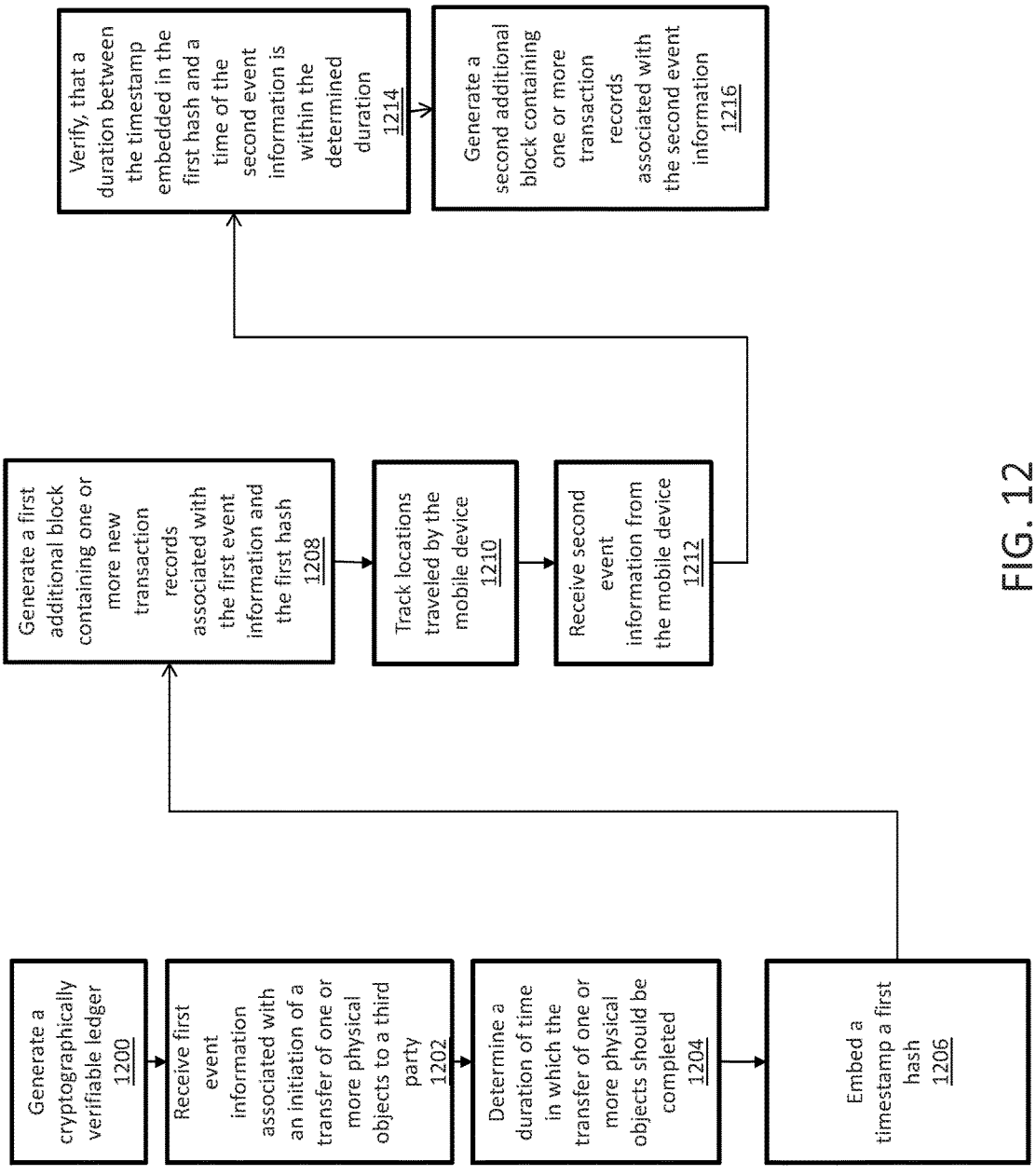

Generate a cryptographically verifiable ledger 1200
Receive first event information associated with an initiation of a transfer of one or more physical objects to a third party 1202
Determine a duration of time in which the transfer of one or more physical objects should be completed 1204
Embed a timestamp a first hash 1206
Generate a first additional block containing one or more new transaction records associated with the first event information and the first hash 1208
Track locations traveled by the mobile device 1210
Receive second event information from the mobile device 1212
Verify, that a duration between the timestamp embedded in the first hash and a time of the second event information is within the determined duration 1214
Generate a second additional block containing one or more transaction records associated with the second event information 1216

FIG. 12

SYSTEM AND METHODS FOR LOCATION VERIFICATION WITH BLOCKCHAIN CONTROLS

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims priority to U.S. Provisional Application 62/562,622 filed on Sep. 25, 2017, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] A blockchain may generally refer to a distributed database that maintains a growing and ordered list or chain of records in which each block contains a hash of some or all previous records in the chain to secure the record from tampering and unauthorized revision. The blockchain may be managed in a peer-to-peer network or by a private entity.

BRIEF DESCRIPTION OF THE FIGURES

[0003] Illustrative embodiments are shown by way of example in the accompanying figures and should not be considered as a limitation of the present invention. The accompanying figures, which are incorporated in and constitute a part of this specification, illustrate one or more embodiments of the invention and, together with the description, help to explain the invention. In the figures:

[0004] FIG. **1** is a block diagram of an exemplary mobile device that can be utilized to implement and/or interact with embodiments of a location verification system;

[0005] FIG. **2** illustrates a path including multiple geo-fences in accordance with an exemplary embodiment;

[0006] FIG. **3** illustrates an exemplary network diagram of a location verification system in accordance with an exemplary embodiment;

[0007] FIG. **4** depicts blocks in a blockchain as configured in accordance with an exemplary embodiment;

[0008] FIG. **5** depicts blockchain transactions in accordance with an exemplary embodiment;

[0009] FIG. **6** is a flowchart depicting a sequence of steps performed in an exemplary embodiment;

[0010] FIG. **7** is a flowchart depicting a blockchain update in accordance with an exemplary embodiment;

[0011] FIG. **8** depicts an exemplary system in accordance with an exemplary embodiment;

[0012] FIG. **9** illustrates a block diagram an exemplary computing device in accordance with an exemplary embodiment;

[0013] FIG. **10** depicts an exemplary sequence of steps performed by a location verification system using blockchain controls to verify a route during delivery using location coordinates in an exemplary embodiment;

[0014] FIG. **11** depicts another exemplary sequence of steps performed by a location verification system using blockchain controls to verify a route during delivery using geo-fences in an exemplary embodiment; and

[0015] FIG. **12** is a flowchart illustrating the process of a time based verification system using blockchain controls to verify an elapsed time for delivery in an exemplary embodiment.

DETAILED DESCRIPTION

[0016] Described in detail herein is a location verification system with blockchain controls. In one embodiment, a central computing system generates a cryptographically verifiable ledger and receives first event information associated with an initiation of a transfer of one or more physical objects to a third party. In response to receiving the first event information the central computing system generates, in the cryptographically verifiable ledger, first additional block information associated with the first event information that includes multiple location coordinates and a first hash. The central computing system can verify that the locations traveled by the mobile device correspond with a path between the location coordinates embedded in the first hash. The central computing system can then generate a second additional block containing one or more transaction records associated with the second event information in response to the verification.

[0017] In one embodiment, the location verification system includes a mobile device equipped with a processor and a location-based sensor. The system further includes a central computing system in communication with the mobile device. The central computing system is configured to generate a cryptographically verifiable ledger represented by a sequence of data blocks. Each data block contains one or more transaction records and each subsequent data block contains a hash value associated with a previous data block. The central computing system is further configured to receive first event information associated with an initiation of a transfer of one or more physical objects to a third party. The first event information includes a destination location associated with the third party. The central computing system is further configured to generate a path from an origin location to the destination location associated with the third party, embed a plurality of location coordinates associated with different locations on the path into a first hash, and generate in the cryptographically verifiable ledger, in response to receiving the first event information, at least a first additional block containing one or more new transaction records associated with the first event information and the first hash. The central computing system is also configured to track locations traveled by the mobile device by receiving location data from the location-based sensor and to receive second event information from the mobile device. The second event information is associated with a completion of the transfer of one or more physical objects to the third party. Additionally the central computing system is configured to verify that the locations traveled by the mobile device correspond with the path embedded in the first hash by verifying that the locations traveled by the mobile device correspond with the location coordinates associated with different locations on the path embedded in the first hash, and to generate at least a second additional block containing one or more transaction records associated with the second event information in response to the verifying.

[0018] In an embodiment, a location verification method includes generating, via a central computing system in communication with a mobile device, a cryptographically verifiable ledger represented by a sequence of data blocks. Each data block contains one or more transaction records and each subsequent data block contains a hash value associated with a previous data block. The mobile device is equipped with a processor and a location-based sensor. The method further includes receiving, via the central computing system, first event information associated with an initiation of a transfer of one or more physical objects to a third party. The first event information includes a destination location

associated with the third party. The method further includes generating, with the central computing system, a path from an origin location to the destination location associated with the third party, and embedding, with the central computing system, location coordinates associated with different locations on the path into a first hash. The method also includes generating in the cryptographically verifiable ledger, via the central computing system, in response to receiving the first event information, at least a first additional block containing one or more new transaction records associated with the first event information and the first hash. The method further includes tracking, via the central computing system, locations traveled by the mobile device by receiving location data from the location-based sensor and second event information from the mobile device, the second event information associated with a completion of the transfer of one or more physical objects to the third party. The method additionally verifies, via the central computing system, that the locations traveled by the mobile device correspond with the path embedded in the first hash by verifying that the locations traveled by the mobile device correspond with the location coordinates associated with different locations on the path embedded in the first hash, and generating at least a second additional block containing one or more transaction records associated with the second event information in response to the verifying.

[0019] FIG. **1** is a block diagram of a mobile device that can be utilized to implement and/or interact with embodiments of a location verification system in an exemplary embodiment. The mobile device **100** can be a smartphone, tablet, subnotebook, laptop, personal digital assistant (PDA), handheld device, such as a Symbol® MC18 and/or any other suitable mobile device that can be programmed and/or configured to implement and/or interact with embodiments of the system via wireless communication. For example, the mobile device **100** can be a Symbol® MC18. Symbol® MC18 can be a handheld mobile computer configured to execute the Android and/or Windows operating system. The Symbol® MC18 can include 1D and 2D Scanner, Wi-Fi (802.11a/b/g/n), Camera, VGA Display, Android 2.3 and/or Windows 7, 1 GB RAM/8 GB Flash, Standard Battery.

[0020] The mobile device **100** can include a processing device **104**, such as a digital signal processor (DSP) or microprocessor, memory/storage **106** in the form a non-transitory computer-readable medium, an image capture device **108**, a touch-sensitive display **110**, a power source **112**, a radio frequency transceiver **114** and a reader **130**. Some embodiments of the mobile device **100** can also include other common components commonly, such as sensors **116**, subscriber identity module (SIM) card **118**, audio input/output components **120** and **122** (including e.g., one or more microphones and one or more speakers), and power management circuitry **124**. The sensors **116** can include a location-based sensor **134**, configured to determine the location of the mobile device **100**.

[0021] The memory **106** can include any suitable, non-transitory computer-readable storage medium, e.g., read-only memory (ROM), erasable programmable ROM (EPROM), electrically-erasable programmable ROM (EEPROM), flash memory, and the like. In exemplary embodiments, an operating system **126** and applications **128** can be embodied as computer-readable/executable program code stored on the non-transitory computer-readable memory **106** and implemented using any suitable, high or low level computing language and/or platform, such as, e.g., Java, C, C++, C#, assembly code, machine readable language, and the like. In some embodiments, the applications **128** can include a facility application configured to interact with the microphone, a web browser application, a mobile application specifically coded to interface with one or more servers of embodiments of the system for data transfer in a distributed environment. One or more servers are described in further detail with respect to FIG. **3**. While memory is depicted as a single component those skilled in the art will recognize that the memory can be formed from multiple components and that separate non-volatile and volatile memory devices can be used.

[0022] The processing device **104** can include any suitable single- or multiple-core microprocessor of any suitable architecture that is capable of implementing and/or facilitating an operation of the mobile device **100**. For example, a user can use the mobile device **100** in a facility to perform an image capture operation, capture a voice input of the user (e.g., via the microphone), transmit messages including a captured image and/or a voice input and receive messages from a central computing system, display data/information including GUIs of the user interface **110**, captured images, voice input transcribed as text, and the like. The mobile device **100** can perform the aforementioned operations using on an internet browser executing on the mobile device, or any web-based application. The processing device **104** can be programmed and/or configured to execute the operating system **126** and applications **128** to implement one or more processes and/or perform one or more operations. The processing device **104** can retrieve information/data from and store information/data to the storage device **106**.

[0023] The RF transceiver **114** can be configured to transmit and/or receive wireless transmissions via an antenna **115**. For example, the RF transceiver **114** can be configured to transmit data/information, such as input based on user interaction with the mobile device **100**. The RF transceiver **114** can be configured to transmit and/or receive data/information having at a specified frequency and/or according to a specified sequence and/or packet arrangement.

[0024] The touch-sensitive display **110** can render user interfaces, such as graphical user interfaces to a user and in some embodiments can provide a mechanism that allows the user to interact with the GUIs. For example, a user may interact with the mobile device **100** through touch-sensitive display **110**, which may be implemented as a liquid crystal touch-screen (or haptic) display, a light emitting diode touch-screen display, and/or any other suitable display device, which may display one or more user interfaces (e.g., GUIs) that may be provided in accordance with exemplary embodiments.

[0025] The power source **112** can be implemented as a battery or capacitive elements configured to store an electric charge and power the mobile device **100**. In exemplary embodiments, the power source **112** can be a rechargeable power source, such as a battery or one or more capacitive elements configured to be recharged via a connection to an external power supply. The scanner **130** can be implemented as an optical reader configured to scan and decode machine-readable elements disposed on objects.

[0026] In one embodiment, the mobile device can execute an object transfer application **132**. The object transfer application **132** can be an executable configured to track the

location of the mobile device **100**. The object transfer application **132** can store the coordinates traveled by the mobile device in response to executing the object transfer application **132** at an origin. The mobile device **100** can store the coordinates after a specified time interval. The mobile device **100** can transmit all the stored coordinates to a central computing system in response to closing the session of the object transfer application **132** and/or in response to the location based sensor detecting a specified location. Alternatively, the mobile device **100** cans transmit the location coordinates to the central computing system when storing or at some other pre-determined interval or event. The session of the object transfer application **132** can be closed upon reaching a destination. In one embodiment, the central computing system can control the operation of the object transfer application **132**. The central computing system can execute the object transfer application **132** and close the session of the object transfer application **132**. For example, the central computing system can detect that the mobile device **100** has reached a destination, based on the location of the mobile device **100**, and close out the session of the object transfer application **132**. The central computing system is described herein with respect to FIG. **3**.

[0027] FIG. **2** illustrates a path including multiple geo-fences in accordance with an exemplary embodiment. In one embodiment, a central computing system can determine a path **200** from an original location **202** to a destination location **204** as indicated by the arrow **206**. The central computing system can determine multiple geo-fences **208** along the path **200**. The geo-fences **208** can be of a specified radius and can be made up of specified coordinates. Each geo-fence can be the same or different radius of another geo-fence along the same path **200**. The central computing system can determine the geo fences **208** by calculating range of locations based on a specified radius and the coordinates of the origin location **202** and the destination location **204**. The central computing system is discussed in further detail with respect to FIG. **3**.

[0028] FIG. **3** illustrates an exemplary network diagram of a location verification system in accordance with an exemplary embodiment. The location verification system **350** can include one or more data storage devices **305**, one or more central computing systems **300**, one or more mobile devices **100**, and one or more third party systems **340**. The central computing system **300** can be in communication with the data storage devices **305**, the mobile device **100**, and the third party systems **340** via a communications network **315**. The mobile device **100** can be associated with a user responsible for delivering one or more physical objects to a third party and can execute an object transfer application **132**. The central computing system **400** can execute at least one instance of a control engine **320**. The control engine **420** can be an executable application executed on the central computing system **300**. The control engine **320** can execute the process of the location verification system **350** as described herein. The central computing system **300** can include one or more nodes **325**. Each of the one or more nodes **325** can store a copy of a blockchain record and/or a shared ledger associated with the transfer of one or more physical objects. The one or more nodes **325** can be configured to update the blocks in the blockchain record based on the operation of transfer of one or more physical objects.

[0029] In an example embodiment, one or more portions of the communications network **415** can be an ad hoc network, an intranet, an extranet, a virtual private network (VPN), a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a wireless wide area network (WWAN), a metropolitan area network (MAN), a portion of the Internet, a portion of the Public Switched Telephone Network (PSTN), a cellular telephone network, a wireless network, a WiFi network, a WiMax network, another type of network, or a combination of two or more such networks.

[0030] The central computing system **300** includes one or more computers or processors configured to communicate with the data storage devices **305**, the mobile devices **100** and third party systems **340**. The data storage devices **305** can store information/data, as described herein. For example, the data storage devices **305** can include a physical objects database **335** and a transfer blockchain **330**. The physical objects database **435** can include information associated with physical objects and a representation of physical objects. The transfer blockchain **330** can be embodied as a blockchain storage system that is configured to store a blockchain record or a shared ledger based on a transfer of physical objects to a third party. For example, the blockchain storage system can store digital licenses, invoices, receipts, or rights of ownership associated with physical objects and the central computing system **300** can use the blocks of the blockchain to authorize the transfer of ownership of physical objects. The data storage devices **305** and the central computing system **300** can be located at one or more geographically distributed locations from each other. Alternatively, the data storage devices **305** can be included within the central computing system **300**.

[0031] In exemplary embodiments, the central computing system **300** can receive an event. The event can include information associated with initiation of a transfer of one or more physical objects to a third party. The event can also include identifiers associated with the one or more physical objects and a destination location, associated with the third party, for the delivery of the one or more physical objects. The central computing system **300** can execute the control engine **320** in response to receiving the event. The control engine **320** can query the physical objects database **330** to retrieve information associated with the one or more physical objects using the identifiers.

[0032] The control engine **320** can generate a path from an origin location to the destination location. The origin location can be a location of the one or more physical objects and/or a specified location. The control engine **320** can determine GPS coordinates for the origin location, one or more interim locations and the destination location. The control engine **320** can generate a hash key embedded with the GPS coordinates for the origin location and the destination location.

[0033] In one embodiment, the control engine **320** can calculate and identify multiple geo-fences along the path. Each of the geo-fences can be made up of GPS coordinates encompassing a specified radius. Each geo-fence can be of a same or different radius. The control engine **320** can generate a hash key embedded with the GPS coordinates encompassing each of the geo-fences, along with the GPS coordinates of the origin and destination location.

[0034] The information associated with the event can be stored in the transfer blockchain database **330** using the blockchain storage system. For example, the node **325** can generate a block in the transfer blockchain database **330**.

The block can store the information associated with the event along with the generated hash key. As noted above, the information can include information associated with ownership of the one or more physical objects. A private and public key can also be associated with the block storing the information associated with the event. Each of the blocks can include a public key and a private key. A user can grant access to another user by providing the public and private key to the block storing the information associated with the event. The other user can attempt to access the information associated with the event using the public and private key of the block. The node **325** can verify the public and private key of the block and provide access to the information associated with the event in response to verification.

[0035] The control engine **320** can transfer an alert to the mobile device **100** to initiate the transfer of the one or more physical objects. As noted above, the mobile device **100** can execute an object transfer application **132**. The mobile device **100** can receive the alert with the object transfer application **132**. In response to receiving the alert the location based sensor **134** in the mobile device **100** can start tracking and storing GPS coordinates traveled by the mobile device. In some embodiments, the object transfer application **132** may not be executing on the mobile device **100**, and in response to receiving the alert, the mobile device **100** can automatically launch the object transfer application **132**.

[0036] As noted above, the mobile device **100** can be associated with a user responsible for delivery of the one or more physical objects to the third party. The user can travel from the origin location to the destination location with the one or more physical objects and the mobile device **100**. The object transfer application **132** can track and record, via the location based sensor **134**, the GPS coordinates traveled by the mobile device **100**. The object transfer application **132** can transmit an alert (i.e. another event) to the central computing system **300** in response to reaching the destination location. The event can include information associated with the completion of the transfer of one or more physical goods. In some embodiments, the object transfer application **132** can automatically transmit the alert to the central computing system in response to the location based sensor **134** determining the mobile device **100** is at the destination location. The alert can include the GPS coordinates traveled by the mobile device **100** along the route between origin and destination.

[0037] In one embodiment, the control engine **320** can verify the mobile device **100** traveled the generated path by comparing the received GPS coordinates traveled by the mobile device **100** with the GPS coordinates of the geo-fences embedded in the hash key stored in the block including information associated with the event and the hash key. The control engine **320** can verify the transfer of the one or more physical objects, by verifying that the mobile device **100** has traveled the generated path from the origin location to the destination location and stayed within the specified radii of geo-fences along the path.

[0038] In response to verifying the transfer of the one or more physical objects, the node **335** can generate a subsequent block including transaction records of transferring the one or more physical objects to the third party. Each new block created that is associated with transferring the one or more physical objects can include a hash key associated with the previous block. The hash key can include the GPS coordinates traveled by the mobile device **100**. This can be referred to as a chain. For example, each time the one or more physical objects are transferred a block may be generated including transaction records associated the transfer of the physical objects. The new block can include a hash key of the block containing a digital license file. The control engine **320** can transmit the public and private key of the block including the information associated the event to provide access to a third party system **340** of the third party, in response to verifying the transfer of the one or more physical objects.

[0039] In one embodiment, "side chains" can also be created. For example, in the event that the control engine **320** is unable to verify the mobile device **100** traveled the generated path a new block can be generated including transaction records of a failure to transfer the one or more physical objects to the third party. For example, this may occur by comparing the received GPS coordinates traveled by the mobile device **100** with the GPS coordinates of the geo-fences embedded in the hash key stored in the block including information associated with the event and the hash key. The control engine **320** can transmit an alert to the third party system **340**. The newly generated block may not include a hash key of the block including information associated with the event. Accordingly, the block containing the information associated with the event can be linked in two different chains.

[0040] In one embodiment, in addition to verifying a route or as a separate procedure, the transfer of the one or more physical objects can be verified based on the duration of time between delivery of the of the one or more physical objects. For example, in response to receiving the event associated with the initiation of transfer of the one or more physical objects, control engine **320** can generate a hash key embedded with a timestamp indicating a time the event was received. The node **325** can generate a block in the transfer blockchain database **330**. The block can store the information associated with the event along with the generated hash key embedded with the timestamp. The object transfer application **132** can transmit an alert to the central computing system **300** in response to reaching the destination location. The alert can include a time of arrival at the destination location. The control engine **320** can verify the transfer of the one or more physical objects in response to determining the duration between the time of arrival at the destination location and the timestamp embedded in the hash is within a specified time period. As noted above, in response to verifying the transfer of the one or more physical objects, the node **335** can generate a subsequent block including transaction records of transferring the one or more physical objects to the third party.

[0041] In one embodiment, in addition to or separately from the embodiments previously discussed, the transfer of the one or more physical objects can be verified based on a hash key received from the third party system **340**. For example, in response to the central computing system **300** receiving an alert to from the object transfer application **132** when the mobile device **132** reaches the destination location, the control engine **320** can generate a new hash key. The new hash key can be different than the hash key stored in the block including the information associated with the event. The new hash key can be configured to be paired with the hash key stored in the block including the information associated with the event. The control engine **320** can transmit the new hash key to the third party system **340**.

[0042] The third party system **340** can transmit the new hash key to the mobile device **100**. The object transfer application **132** can transmit the new hash key to the central computing system **300**. The control engine **320** may attempt to pair the new hash key with the hash key stored in the block with the information associated with the event. In response to successfully pairing the new hash key with the hash key stored in the block with the information associated with the event, the control engine **320** can verify the transfer of the one or physical objects.

[0043] As a non-limiting example, the location verification system **350** can be implemented as in a retail store and/or e-commerce website. For example, the central computing system **300** can receive an event associated with the request to deliver products from a retail store to a third party. The third party can be a customer, charity organization, vendor and/or supplier. The products can be perishable items.

[0044] In one example, in response to the central computing system **300** receiving a request for delivery of perishable items, the control engine **350** can query the physical objects database **335** to determine an expiration date and time of the perishable items. The control engine **350** can generate a hash key embedded with a timestamp associated with the expiration date and time of the perishable items. The node **325** can generate a block in the transfer blockchain database **330**. The block can store the information associated with the event along with the generated hash key. The block can store the information associated with the event along with the generated hash key embedded with the timestamp. The object transfer application **132** can transmit an alert to the central computing system **300** in response to reaching the destination location. The alert can include a time of arrival at the destination location. The control engine **320** can verify the transfer of the one or more physical objects in response to determining the duration between the time of arrival at the destination location and the timestamp embedded in the hash is within a specified time period. As noted above, in response to verifying the transfer of the one or more physical objects, the node **335** can generate a subsequent block including transaction records of delivery of the perishable items to the third party.

[0045] Descriptions of some embodiments of blockchain technology are provided with reference to FIGS. **4-8** herein. In some embodiments, blockchain technology may be utilized to verify the transfer of physical objects as described herein. One or more of the central computing systems described herein may include a node in a distributed blockchain system storing a copy of the blockchain record. Updates to the blockchain may include information associated with requests for transferring one or more physical objects, and one or more nodes on the system may be configured to incorporate one or more updates into blocks to add to the distributed database.

[0046] Distributed database and shared ledger database generally refer to methods of peer-to-peer record keeping and authentication in which records are kept at multiple nodes in the peer-to-peer network instead of being kept at a trusted party. However, exemplary embodiments of the present disclosure can also utilize a private (trusted) system to maintain the blockchains. A blockchain may generally refer to a distributed database that maintains a growing and ordered list or chain of records in which each block contains a hash of some or all previous records in the chain to secure the record from tampering and unauthorized revision. A hash generally refers to a derivation of original data. In some embodiments, the hash in a block of a blockchain may include a cryptographic hash that is difficult to reverse and/or a hash table. Blocks in a blockchain may further be secured by a system involving one or more of a distributed timestamp server, cryptography, public/private key authentication and encryption, proof standard (e.g. proof-of-work, proof-of-stake, proof-of-space), and/or other security, consensus, and incentive features. In some embodiments, a block in a blockchain may include one or more of a data hash of the previous block, a timestamp, a cryptographic nonce, a proof standard, and a data descriptor to support the security and/or incentive features of the system.

[0047] In some embodiments, the location verification system includes a distributed timestamp server including multiple nodes configured to generate computational proof of record integrity and the chronological order of its use for content, trade, and/or as a currency of exchange through a peer-to-peer network. In some embodiments, when a blockchain is updated, a node in the distributed timestamp server system takes a hash of a block of items to be timestamped and broadcasts the hash to other nodes on the peer-to-peer network. The timestamp in the block serves to prove that the data existed at the time in order to get into the hash. In some embodiments, each block includes the previous timestamp in its hash, forming a chain, with each additional block reinforcing the ones before it. In some embodiments, the network of timestamp server nodes performs the following steps to add a block to a chain: 1) new activities are broadcasted to all nodes, e.g., resulting from in-field authentication of autonomous electronic devices, 2) each node collects new activities into a block, 3) each node works on finding a difficult proof-of-work for its block, 4) when a node finds a proof-of-work, it broadcasts the block to all nodes, 5) nodes accept the block only if activities are authorized, and 6) nodes express their acceptance of the block by working on creating the next block in the chain, using the hash of the accepted block as the previous hash. In some embodiments, nodes may be configured to consider the longest chain to be the correct one and work on extending it.

[0048] Now referring to FIG. **4**, an illustration of a blockchain according to embodiments of the present disclosure is shown. As mentioned in above, with reference to FIG. **3**, a blockchain includes a hash chain or a hash tree in which each block added in the chain contains a hash of the previous block. In FIG. **4**, block **0 400** represents a genesis block of the chain and can be generated in response to initiation of a request to transfer one or more physical objects. The block **0 400** can include information associated with the transfer of the one or more physical objects and a hash key embedded with one or more of GPS coordinates of the origin location, destination location, a path from the origin location and destination location, geo-fences along the path from the origin location and destination location, GPS coordinates encompassing each of the geo-fences, and a timestamp. The information associated with the transfer of the one or more physical objects can include information associated with the physical objects and information associated with the ownership of the one or more physical objects. Block **1 410** can be generated in response to a verification of the transfer of the one or more physical objects. The block **1 410** can contain a hash of block **0 400**. If the transfer of one or more

physical objects is verified the block **1 410** can include the information associated with the transfer of the one or more physical objects. Otherwise, the block **1 410** can include information indicating a transfer was not verified. Additional blocks can be generated as additional requests are received and each block that is generated can include a hash of a previous block. For example, block **2 420** can be generated in response to a subsequent request and can contain a hash of block **1 410**, block **3 430** can be generated in response to a yet another subsequent request and can contain a hash of block **2 420**, and so forth. Continuing down the chain, block N contains a hash of block N−1. In some embodiments, the hash may include the header of each block. Once a chain is formed, modifying or tampering with a block in the chain would cause detectable disparities between the blocks. For example, if block **1** is modified after being formed, block **1** would no longer match the hash of block **1** in block **2**. If the hash of block **1** in block **2** is also modified in an attempt to cover up the change in block **1**, block **2** would not then match with the hash of block **2** in block **3**. In some embodiments, a proof standard (e.g. proof-of-work, proof-of-stake, proof-of-space, etc.) may be required by the system when a block is formed to increase the cost of generating or changing a block that could be authenticated by the consensus rules of the distributed system, making the tampering of records stored in a blockchain computationally costly and essentially impractical. In some embodiments, a blockchain may include a hash chain stored on multiple nodes as a distributed database and/or a shared ledger, such that modifications to any one copy of the chain would be detectable when the system attempts to achieve consensus prior to adding a new block to the chain. In some embodiments, a block may generally contain any type of data and record. In some embodiments, each block may include a plurality of transaction and/or activity records.

[0049] In some embodiments, the blocks generated by the central computing system can contain rules and data for authorizing different types of actions and/or parties who can take action as described herein. In some embodiments, transaction and block forming rules may be part of the software algorithm on each node. When a new block is being formed, any node on the system can use the prior records in the blockchain to verify whether the requested action is authorized. For example, a block may contain a public key associated with the user of a user device that purchased/acquired the design file that allows the user to show possession and/or transfer the digital license using a private key. Nodes may verify that the user is in possession of the one or more physical objects and/or is authorized to transfer the one or more physical objects based on prior transaction records when a block containing the transaction is being formed and/or verified. In some embodiments, rules themselves may be stored in the blockchain such that the rules are also resistant to tampering once created and hashed into a block. In some embodiments, the blockchain system may further include incentive features for nodes that provide resources to form blocks for the chain. Nodes can compete to provide proof-of-work to form a new block, and the first successful node of a new block earns a reward.

[0050] Now referring to FIG. **5**, an illustration of blockchain based transactions according to some embodiments is shown. In some embodiments, the blockchain illustrated in FIG. **5** includes a hash chain protected by private/public key encryption. Transaction A **510** represents a transaction recorded in a block of a blockchain showing that owner **1** (recipient) (e.g., a first user of the first user device acquired the physical objects from owner **0**). Transaction A **510** contains owner's **1** public key and owner **0**'s signature for the transaction and a hash of a previous block. When owner **1** (e.g., the first user of the first user device who purchased and/or acquired the design) transfers the design file to owner **2** (e.g., a second user of a second user device), a block containing transaction B **520** is formed. The record of transaction B **520** includes the public key of owner **2** (recipient), a hash of the previous block, and owner **1**'s signature for the transaction that is signed with the owner **1**'s private key **525** and verified using owner **1**'s public key in transaction A **510**. If owner **2** (e.g., the second user) transfers the asset to owner **3** (the third user), a block containing transaction C **530** is formed. The record of transaction C **530** includes the public key of owner **3** (recipient), a hash of the previous block, and owner **2**'s signature for the transaction that is signed by owner **2**'s private key **535** and verified using owner **2**'s public key from transaction B **620**. In some embodiments, when each transaction record is created, the system may check previous transaction records and the current owner's private and public key signature to determine whether the transaction is valid. In some embodiments, transactions are be broadcasted in the peer-to-peer network and each node on the system may verify that the transaction is valid prior to adding the block containing the transaction to their copy of the blockchain. In some embodiments, nodes in the system may look for the longest chain in the system to determine the most up-to-date transaction record to prevent the current owner from double spending the asset. The transactions in FIG. **5** are shown as an example only. In some embodiments, a blockchain record and/or the software algorithm may include any type of rules that regulate who and how the chain may be extended. In some embodiments, the rules in a blockchain may include clauses of a smart contract that is enforced by the peer-to-peer network.

[0051] Now referring to FIG. **6**, a flow diagram according to some embodiments is shown. In some embodiments, the steps shown in FIG. **6** may be performed by a computer system as described in FIG. **3**, a server, a distributed server, a timestamp server, a blockchain node, and the like. In some embodiments, the steps in FIG. **6** may be performed by one or more of the nodes in a system using blockchain for record keeping.

[0052] In step **601**, a node receives a new activity in response to a request for transfer of one or more physical objects. The new activity may include an update to the record being kept in the form of a blockchain. In some embodiments, for blockchain supported digital or physical record keeping, the new activity can correspond to the ownership of the one or more physical objects and/or the transfer of the ownership of the physical objects from a first user device to a second user device. In some embodiments, the new activity may be broadcasted to a plurality of nodes on the network prior to step **601**. In step **602**, the node works to form a block to update the blockchain. In some embodiments, a block may include a plurality of activities or updates and a hash of one or more previous block in the blockchain. In some embodiments, the system may include consensus rules for individual transactions and/or blocks and the node may work to form a block that conforms to the consensus rules of the system. In some embodiments, the consensus rules may be specified in the software program

running on the node. For example, a node may be required to provide a proof standard (e.g. proof of work, proof of stake, etc.) which requires the node to solve a difficult mathematical problem for form a nonce in order to form a block. In some embodiments, the node may be configured to verify that the activity is authorized prior to working to form the block. In some embodiments, whether the activity is authorized may be determined based on records in the earlier blocks of the blockchain itself.

[0053] After step **602**, if the node successfully forms a block in step **605** prior to receiving a block from another node, the node broadcasts the block to other nodes over the network in step **606**. In step **620**, the node then adds the block to its copy of the blockchain. In the event that the node receives a block formed by another node in step **603** prior to being able to form the block, the node works to verify that the activity (e.g., authentication of transfer) recorded in the received block is authorized in step **604**. In some embodiments, the node may further check the new block against system consensus rules for blocks and activities to verify whether the block is properly formed. If the new block is not authorized, the node may reject the block update and return to step **602** to continue to work to form the block. If the new block is verified by the node, the node may express its approval by adding the received block to its copy of the blockchain in step **620**. After a block is added, the node then returns to step **601** to form the next block using the newly extended blockchain for the hash in the new block.

[0054] In some embodiments, in the event one or more blocks having the same block number is received after step **620**, the node may verify the later arriving blocks and temporarily store these blocks if they pass verification. When a subsequent block is received from another node, the node may then use the subsequent block to determine which of the received blocks is the correct/consensus block for the blockchain system on the distributed database and update its copy of the blockchain accordingly. In some embodiments, if a node goes offline for a time period, the node may retrieve the longest chain in the distributed system, verify each new block added since it has been offline, and update its local copy of the blockchain prior to proceeding to step **601**.

[0055] Now referring to FIG. **7**, a process diagram for a blockchain update according to some embodiments is shown. In step **701**, party A (the first user device) initiates the delivery and transfer one or more physical objects to party B (the second user device). In some embodiments, Party A may be authenticated by signing the transaction with a private key that may be verified with a public key in the previous transaction associated with the physical objects are to be transferred. In step **702**, the authentication initiated in step **701** is represented as a block. In some embodiments, the transaction may be compared with transaction records in the longest chain in the distributed system to verify part A's authentication. In some embodiments, a plurality of nodes in the network may compete to form the block containing the authentication record. In some embodiments, nodes may be required to satisfy proof-of-work by solving a difficult mathematical problem to form the block. In some embodiments, other methods of proof such as proof-of-stake, proof-of-space, etc. may be used in the system. In step **703**, the block is broadcasted to parties in the network. In step **704**, nodes in the network authenticate party A by examining the block that contains the party A's authentication. In some embodiments, the nodes may check the solution provided as proof-of-work to approve the block. In some embodiments, the nodes may check the transaction against the transaction record in the longest blockchain in the system to verify that the transaction is valid (e.g. party A is in possession of the object to be transferred). In some embodiments, a block may be approved with consensus of the nodes in the network. After a block is approved, the new block **706** representing the authentication is added to the existing chain **705** including blocks that chronologically precede the new block **706**. The new block **706** may contain the transaction(s) and a hash of one or more blocks in the existing chain **705**. In some embodiments, each node may then update their copy of the blockchain with the new block and continue to work on extending the chain with additional transactions. In step **707**, when the chain is updated with the new block, the physical objects can be transferred from party A to party B (e.g., from the first mobile autonomous electronic device to the second autonomous electronic device).

[0056] Now referring to FIG. **8**, a system according to some embodiments is shown. A location verification system includes a plurality of nodes **810** communicating over a network **820**. In some embodiments, the nodes **810** may include a distributed blockchain server and/or a distributed timestamp server. Each node **810** in the system includes a network interface **811**, a control circuit **812**, and a memory **813**.

[0057] The control circuit **812** may include a processor, a microprocessor, and the like and may be configured to execute computer readable instructions stored on a computer readable storage memory **813**. The computer readable storage memory may include volatile and/or non-volatile memory and have stored upon it a set of computer readable instructions which, when executed by the control circuit **812**, causes the node **810** update the blockchain **814** stored in the memory **813** based on communications with other nodes **810** over the network **820**. In some embodiments, the control circuit **812** may further be configured to extend the blockchain **814** by processing updates to form new blocks for the blockchain **814**. Generally, each node may store a version of the blockchain **814**, and together, may form a distributed database. In some embodiments, each node **810** may be configured to perform one or more steps described with reference to FIGS. **6-8** herein.

[0058] The network interface **811** may include one or more network devices configured to allow the control circuit to receive and transmit information via the network **820**. In some embodiments, the network interface **811** may include one or more of a network adapter, a modem, a router, a data port, a transceiver, and the like. The network **820** may include a communication network configured to allow one or more nodes **810** to exchange data. In some embodiments, the network **820** may include one or more of the Internet, a local area network, a private network, a virtual private network, a home network, a wired network, a wireless network, and the like. In some embodiments, the system does not include a central server and/or a trusted third party system. Each node in the system may enter and leave the network at any time.

[0059] With the system and processes shown, once a block is formed, the block cannot be changed without redoing the work to satisfy census rules thereby securing the block from tampering. A malicious attacker would need to provide proof standard for each block subsequent to the one he/she seeks

to modify, race all other nodes, and overtake the majority of the system to affect change to an earlier record in the blockchain.

[0060] In some embodiments, blockchain may be used to support a payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. A blockchain system uses a peer-to-peer distributed timestamp server to generate computational proof of the chronological order of transactions. Generally, a blockchain system is secure as long as honest nodes collectively control more processing power than any cooperating group of attacker nodes. With a blockchain, the transaction records are computationally impractical to reverse. As such, sellers are protected from fraud and buyers are protected by the routine escrow mechanism.

[0061] In some embodiments, in the peer-to-peer network, the longest chain proves the sequence of events witnessed, proves that it came from the largest pool of processing power, and that the integrity of the document has been maintained. In some embodiments, the network for supporting blockchain based record keeping requires minimal structure. In some embodiments, messages for updating the record are broadcast on a best-effort basis. Nodes can leave and rejoin the network at will and may be configured to accept the longest proof-of-work chain as proof of what happened while they were away.

[0062] FIG. **9** is a block diagram of an example computing device for implementing exemplary embodiments of the present disclosure. Embodiments of the computing device **900** can implement embodiments of the location verification system. For example, the computing device can be embodied as a portion of the central computing system and/or third party system. The computing device **900** includes one or more non-transitory computer-readable media for storing one or more computer-executable instructions or software for implementing exemplary embodiments. The non-transitory computer-readable media may include, but are not limited to, one or more types of hardware memory, non-transitory tangible media (for example, one or more magnetic storage disks, one or more optical disks, one or more flash drives, one or more solid state disks), and the like. For example, memory **906** included in the computing device **900** may store computer-readable and computer-executable instructions or software (e.g., applications **930** such as the control engine **320**) for implementing exemplary operations of the computing device **900**. The computing device **900** also includes configurable and/or programmable processor **902** and associated core(s) **904**, and optionally, one or more additional configurable and/or programmable processor(s) **902'** and associated core(s) **904'** (for example, in the case of computer systems having multiple processors/cores), for executing computer-readable and computer-executable instructions or software stored in the memory **906** and other programs for implementing exemplary embodiments of the present disclosure. Processor **902** and processor(s) **902'** may each be a single core processor or multiple core (**904** and **904'**) processor. Either or both of processor **902** and processor(s) **902'** may be configured to execute one or more of the instructions described in connection with computing device **900**.

[0063] Virtualization may be employed in the computing device **900** so that infrastructure and resources in the computing device **900** may be shared dynamically. A virtual machine **912** may be provided to handle a process running on multiple processors so that the process appears to be using only one computing resource rather than multiple computing resources. Multiple virtual machines may also be used with one processor.

[0064] Memory **906** may include a computer system memory or random access memory, such as DRAM, SRAM, EDO RAM, and the like. Memory **906** may include other types of memory as well, or combinations thereof. The computing device **900** can receive data from input/output devices such as, an image capturing device **934**. The image capturing device **934** can capture still or moving images. A user may interact with the computing device **900** through a visual display device **914**, such as a computer monitor, which may display one or more graphical user interfaces **916**, multi touch interface **920** and a pointing device **918**.

[0065] The computing device **900** may also include one or more storage devices **926**, such as a hard-drive, CD-ROM, or other computer readable media, for storing data and computer-readable instructions and/or software that implement exemplary embodiments of the present disclosure (e.g., applications such as the control engine **320**). For example, exemplary storage device **926** can include one or more databases **928** for storing information associated with ownership of physical objects and information associated the physical objects. The databases **928** may be updated manually or automatically at any suitable time to add, delete, and/or update one or more data items in the databases.

[0066] The computing device **900** can include a network interface **908** configured to interface via one or more network devices **924** with one or more networks, for example, Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (for example, 802.11, T1, T3, 56 kb, X.25), broadband connections (for example, ISDN, Frame Relay, ATM), wireless connections, controller area network (CAN), or some combination of any or all of the above. In exemplary embodiments, the central computing system can include one or more antennas **922** to facilitate wireless communication (e.g., via the network interface) between the computing device **900** and a network and/or between the computing device **900** and other computing devices. The network interface **908** may include a built-in network adapter, network interface card, PCMCIA network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **900** to any type of network capable of communication and performing the operations described herein.

[0067] The computing device **900** may run any operating system **910**, such as any of the versions of the Microsoft® Windows® operating systems, the different releases of the Unix and Linux operating systems, any version of the MacOS® for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, or any other operating system capable of running on the computing device **900** and performing the operations described herein. In exemplary embodiments, the operating system **910** may be run in native mode or emulated mode. In an exemplary embodiment, the operating system **910** may be run on one or more cloud machine instances.

[0068] FIG. **10** is a flowchart illustrating the process of the location verification system using blockchain controls. In operation **1000**, a central computing system (e.g. central computing system **300** as shown in FIG. **3**) can generate a cryptographically verifiable ledger (e.g. transfer blockchain **330** as shown in FIG. **3**) represented by a sequence of data blocks, each data block containing one or more transaction records and each subsequent data block containing a hash value associated with a previous data block. The central computing system can be in communication with a mobile device (e.g. mobile device **100** as shown in FIGS. **1** and **3**). The mobile device can include a processor (e.g. processor **104** as shown in FIG. **1**) and a location-based sensor (e.g. location based sensor **134** as shown in FIG. **1**).

[0069] In operation **1002**, the central computing system can receive first event information associated with an initiation of a transfer of one or more physical objects to a third party. The first event information includes a destination location (e.g. destination location **204** as shown in FIG. **2**) associated with the third party. In operation **1004**, the central computing system can generate a path (e.g. a path **200** as shown in FIG. **2**) from an origin location (e.g. origin location **202** as shown in FIG. **2**) to the destination location associated with the third party. In operation **1006**, the central computing system can embed location coordinates associated with different locations on the path into a first hash. In operation **1008**, in response to receiving the first event information the central computing system can generate a first additional block containing one or more new transaction records associated with the first event information and the first hash, in the cryptographically verifiable ledger.

[0070] In operation **1010**, the central computing system can track locations traveled by the mobile device by receiving location data from the location-based sensor. In operation **1012**, the central computing system can receive second event information from the mobile device. The second event information can be associated with a completion of the transfer of one or more physical objects to the third party. In operation **1014**, the central computing system can verify, that the locations traveled by the mobile device correspond with the path embedded in the first hash by verifying that the locations traveled by the mobile device correspond with the plurality of location coordinates associated with different locations on the path embedded in the first hash. In operation **1016**, the central computing system can generate a second additional block containing one or more transaction records associated with the second event information in response to the verification.

[0071] FIG. **11** is a flowchart illustrating the process of the location verification system using blockchain controls. In operation **1100**, a central computing system (e.g. central computing system **300** as shown in FIG. **3**) can generate a cryptographically verifiable ledger (e.g. transfer blockchain **330** as shown in FIG. **3**) represented by a sequence of data blocks, each data block containing one or more transaction records and each subsequent data block containing a hash value associated with a previous data block. The central computing system can be in communication with a mobile device (e.g. mobile device **100** as shown in FIGS. **1** and **3**). The mobile device can include a processor (e.g. processor **104** as shown in FIG. **1**) and a location-based sensor (e.g. location based sensor **134** as shown in FIG. **1**).

[0072] In operation **1102**, the central computing system can receive first event information associated with an initiation of a transfer of one or more physical objects to a third party. The first event information includes a destination location (e.g. destination location **204** as shown in FIG. **2**) associated with the third party. In operation **1104**, the central computing system can generate a path (e.g. a path **200** as shown in FIG. **2**) from an origin location (e.g. origin location **202** as shown in FIG. **2**) to the destination location associated with the third party including geo-fences of a specified radius along the path. In operation **1106**, the central computing system can embed location coordinates associated with different locations on the path, including each of the geo-fences, into a first hash. In operation **1108**, in response to receiving the first event information the central computing system can generate a first additional block containing one or more new transaction records associated with the first event information and the first hash, in the cryptographically verifiable ledger.

[0073] In operation **1110**, the central computing system can track locations traveled by the mobile device by receiving location data from the location-based sensor. In operation **1112**, the central computing system can receive second event information from the mobile device. The second event information can be associated with a completion of the transfer of one or more physical objects to the third party. In operation **1114**, the central computing system can verify, that the locations traveled by the mobile device that the locations traveled by the mobile device are within the radius of each of the plurality of geo-fences based on the different locations on the path embedded in the first hash. In operation **1116**, the central computing system can generate a second additional block containing one or more transaction records associated with the second event information in response to the verification.

[0074] FIG. **12** is a flowchart illustrating the process of a time based verification system using blockchain controls. In operation **1200**, a central computing system (e.g. central computing system **300** as shown in FIG. **3**) can generate a cryptographically verifiable ledger (e.g. transfer blockchain **330** as shown in FIG. **3**) represented by a sequence of data blocks, each data block containing one or more transaction records and each subsequent data block containing a hash value associated with a previous data block. The central computing system can be in communication with a mobile device (e.g. mobile device **100** as shown in FIGS. **1** and **3**). The mobile device can include a processor (e.g. processor **104** as shown in FIG. **1**) and a location-based sensor (e.g. location based sensor **134** as shown in FIG. **1**).

[0075] In operation **1202**, the central computing system can receive first event information associated with an initiation of a transfer of one or more physical objects to a third party. The first event information includes a destination location (e.g. destination location **204** as shown in FIG. **2**) associated with the third party. In operation **1204**, the central computing system can determine duration of time in which the transfer of one or more physical objects should be completed. In operation **1206**, the central computing system can embed a time stamp in the first hash. In operation **1208**, in response to receiving the first event information the central computing system can generate a first additional block containing one or more new transaction records associated with the first event information and the first hash, in the cryptographically verifiable ledger.

[0076] In operation **1210**, the central computing system can receive second event information from the mobile

device. The second event information can be associated with a completion of the transfer of one or more physical objects to the third party. In operation **1212**, the central computing system can track a time at which the second event was received from the mobile device. In operation **1214**, the central computing system can verify, that a duration between the timestamp embedded in the first hash and a time of the second event information is within the determined duration. In operation **1216**, the central computing system can generate a second additional block containing one or more transaction records associated with the second event information in response to the verification.

[0077] In describing exemplary embodiments, specific terminology is used for the sake of clarity. For purposes of description, each specific term is intended to at least include all technical and functional equivalents that operate in a similar manner to accomplish a similar purpose. Additionally, in some instances where a particular exemplary embodiment includes a multiple system elements, device components or method steps, those elements, components or steps may be replaced with a single element, component or step. Likewise, a single element, component or step may be replaced with multiple elements, components or steps that serve the same purpose. Moreover, while exemplary embodiments have been shown and described with references to particular embodiments thereof, those of ordinary skill in the art will understand that various substitutions and alterations in form and detail may be made therein without departing from the scope of the present disclosure. Further still, other aspects, functions and advantages are also within the scope of the present disclosure.

[0078] Exemplary flowcharts are provided herein for illustrative purposes and are non-limiting examples of methods. One of ordinary skill in the art will recognize that exemplary methods may include more or fewer steps than those illustrated in the exemplary flowcharts, and that the steps in the exemplary flowcharts may be performed in a different order than the order shown in the illustrative flowcharts.

1. A location based verification system, the system comprising:

a mobile device equipped with a processor and a location-based sensor; and

a central computing system in communication with the mobile device, the central computing system configured to:

generate a cryptographically verifiable ledger represented by a sequence of data blocks, each data block containing one or more transaction records and each subsequent data block containing a hash value associated with a previous data block;

receive first event information associated with an initiation of a transfer of one or more physical objects to a third party, wherein the first event information includes a destination location associated with the third party;

generate a path from an origin location to the destination location associated with the third party;

embed a plurality of location coordinates associated with different locations on the path into a first hash;

generate, in response to receiving the first event information, at least a first additional block containing one or more new transaction records associated with the first event information and the first hash, in the cryptographically verifiable ledger;

track locations traveled by the mobile device by receiving location data from the location-based sensor;

receive second event information from the mobile device, the second event information associated with a completion of the transfer of one or more physical objects to the third party;

verify that the locations traveled by the mobile device correspond with the path embedded in the first hash by verifying that the locations traveled by the mobile device correspond with the plurality of location coordinates associated with different locations on the path embedded in the first hash, and

generate at least a second additional block containing one or more transaction records associated with the second event information in response to the verifying.

2. The system of claim **1**, wherein the path includes a plurality of geo-fences of a specified radius.

3. The system of claim **2**, wherein the central computing system is configured to verify that the locations traveled by the mobile device are within the radius of each of the plurality of geo-fences.

4. The system of claim **1**, wherein the central computing system is configured to embed a timestamp in the first hash.

5. The system of claim **4**, wherein the central computing system is configured to generate the at least second additional block containing the one or more transaction records associated with the second event information in response to also verifying that a duration between the timestamp embedded in the first hash and a time of the second event information is within a specified time period.

6. The system of claim **5**, wherein the one or more physical objects are perishable goods.

7. The system of claim **6**, wherein the central computing system is configured to determine the specified time period based on an expiration date of the perishable goods.

8. The system of claim **1**, wherein the central computing system generates a second hash and transmits the second hash to a system associated with the third party.

9. The system of claim **8**, wherein the system associated with the third party transmits the second hash to the mobile device.

10. The system of claim **9**, wherein the central computing system is configured to generate the at least second additional block containing the one or more transaction records associated with the second event information following a verification of the second hash received by the mobile device.

11. A location based verification method, the method comprising:

generating, via a central computing system in communication with a mobile device, a cryptographically verifiable ledger represented by a sequence of data blocks, each data block containing one or more transaction records and each subsequent data block containing a hash value associated with a previous data block, the mobile device equipped with a processor and a location-based sensor;

receiving, via the central computing system, first event information associated with an initiation of a transfer of one or more physical objects to a third party, wherein the first event information includes a destination location associated with the third party;

generating, via the central computing system, a path from an origin location to the destination location associated with the third party;

embedding, via the central computing system, a plurality of location coordinates associated with different locations on the path into a first hash;

generating, via the central computing system, in response to receiving the first event information, at least a first additional block containing one or more new transaction records associated with the first event information and the first hash, in the cryptographically verifiable ledger;

tracking, via the central computing system, locations traveled by the mobile device by receiving location data from the location-based sensor;

receiving, via the central computing system, second event information from the mobile device, the second event information associated with a completion of the transfer of one or more physical objects to the third party;

verifying, via the central computing system, that the locations traveled by the mobile device correspond with the path embedded in the first hash by verifying that the locations traveled by the mobile device correspond with the plurality of location coordinates associated with different locations on the path embedded in the first hash, and

generating, via the central computing system, at least a second additional block containing one or more transaction records associated with the second event information in response to the verifying.

12. The method of claim **11**, wherein the path includes a plurality of geo-fences of a specified radius.

13. The method of claim **12**, further comprising verifying, via the central computing system, that the locations traveled by the mobile device are within the radius of each of the plurality of geo-fences.

14. The method of claim **11**, further comprising embedding, via the central computing system, a timestamp in the first hash.

15. The method of claim **14**, further comprising generating, via the central computing system, the at least second additional block containing the one or more transaction records associated with the second event information in response to also verifying that a duration between the timestamp embedded in the first hash and a time of the second event information is within a specified time period.

16. The method of claim **15**, wherein the one or more physical objects are perishable goods.

17. The method of claim **16**, further comprising determining, via the central computing system, the specified time period based on an expiration date of the perishable goods.

18. The method of claim **11**, further comprising generating, via the central computing system, a second hash and transmits the second hash to a system associated with the third party.

19. The method of claim **18**, wherein the system associated with the third party transmits the second hash to the mobile device.

20. The method of claim **19**, further comprising generating, via the central computing system, the at least second additional block containing the one or more transaction records associated with the second event information following a verification of the second hash received by the mobile device.

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