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(54) **ZERO KNOWLEDGE PERSONAL ASSISTANT**

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(22) Filed: **Apr. 30, 2025**

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(60) Provisional application No. 63/302,892, filed on Jan. 25, 2022.

Publication Classification

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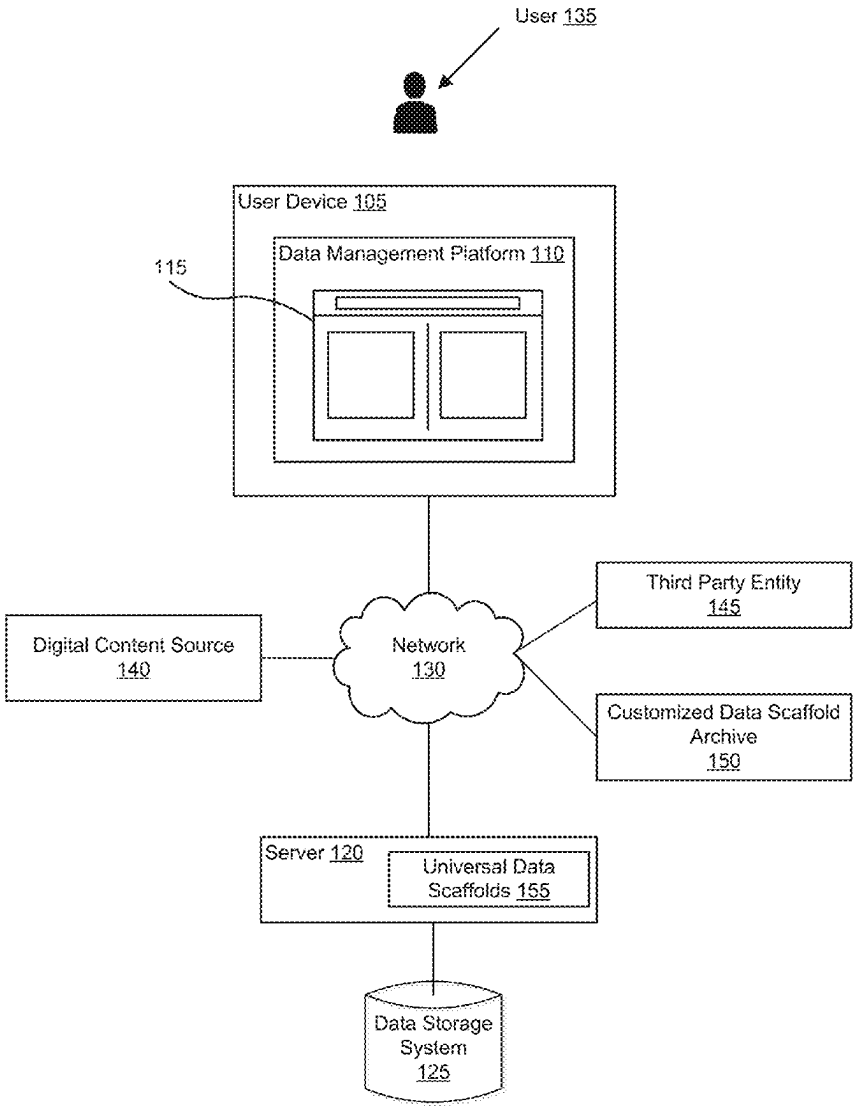
G06F 21/46 (2013.01)

(52) **U.S. Cl.**
CPC ***G06F 21/46*** (2013.01)

(57) **ABSTRACT**

A zero-knowledge personal assistant is enabled by a universal data scaffold. Because the information is mapped to a universal data scaffold in a structured format, a data management platform can easily organize, display, and draw associations between the information. The universal data scaffold and structured user data resides on a user's device, preventing data from being obtained by third parties. To analyze data and produce recommendations for the virtual assistant, a set of rules associated with the universal data scaffold can be applied to the user data. Information can be encrypted and shared between users without being decrypted by a third-party.



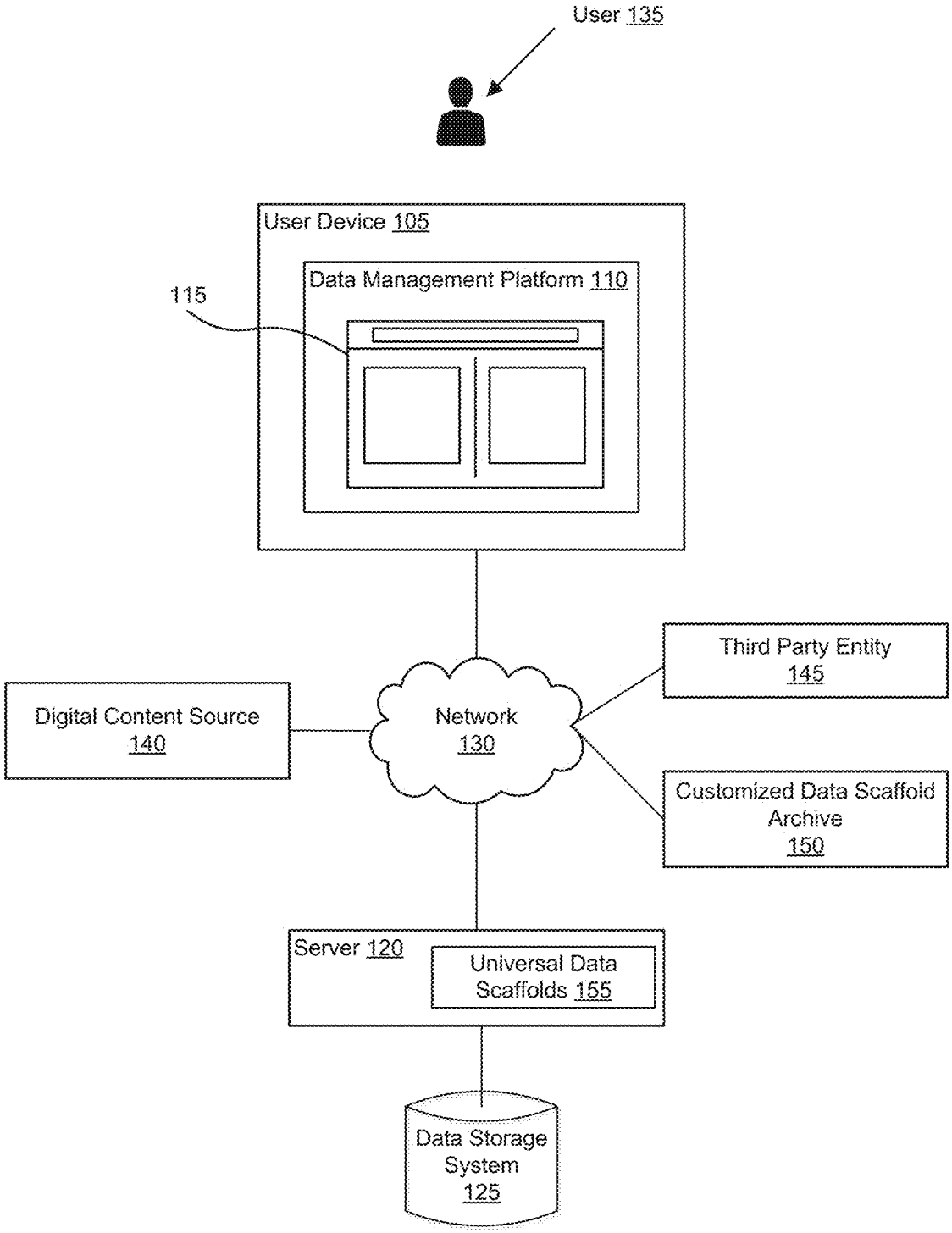

User 135
User Device 105
Data Management Platform 110
115
Third Party Entity
145
Digital Content Source
140
Network
130
Customized Data Scaffold
Archive
150
Server 120
Universal Data
Scaffolds 155
Data Storage
System
125

FIG. 1

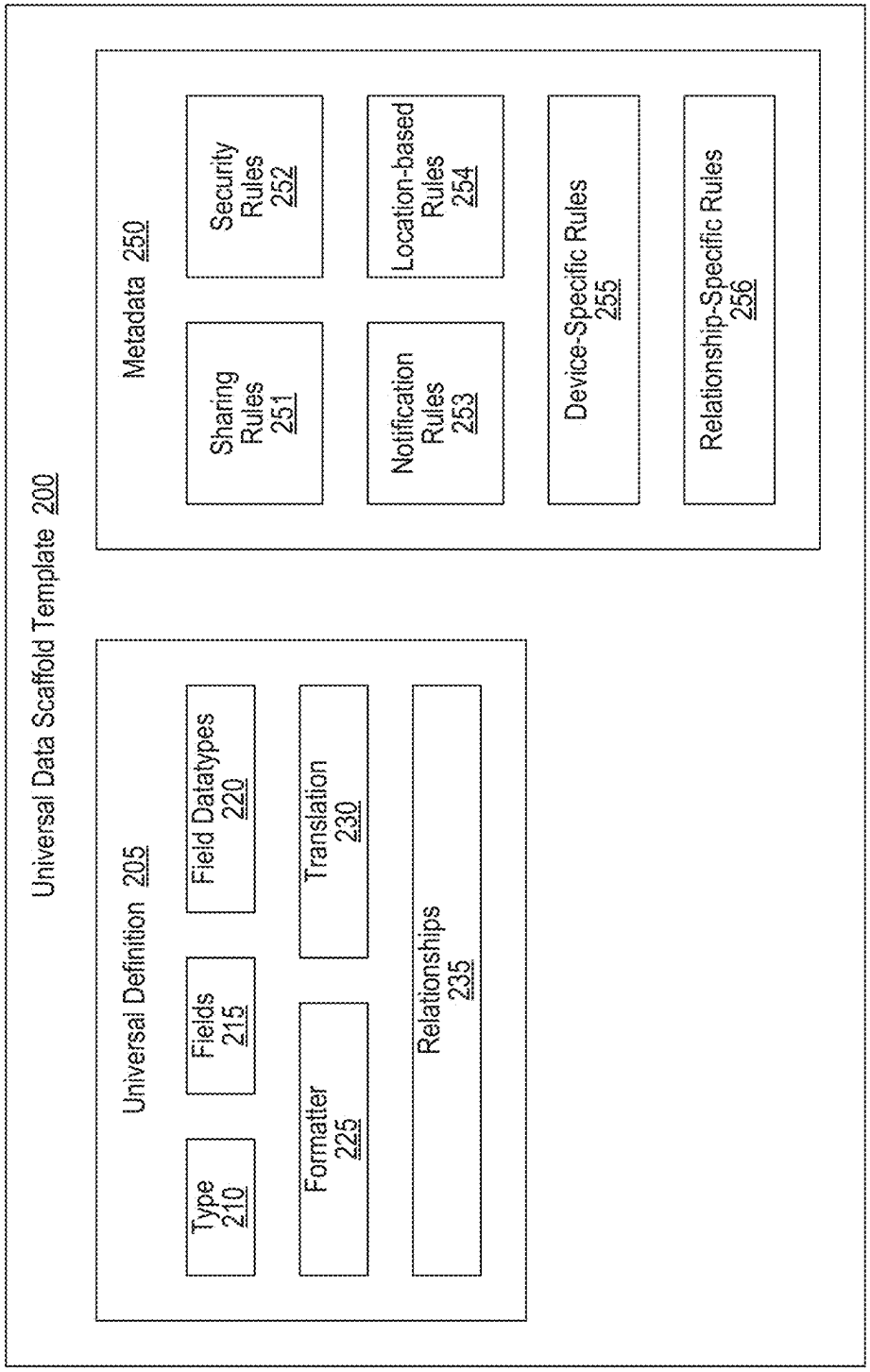

Universal Data Scaffold Template 200
Universal Definition 205
Type 210
Fields 215
Field Datatypes 220
Formatter 225
Translation 230
Relationships 235
Metadata 250
Sharing Rules 251
Security Rules 252
Notification Rules 253
Location-based Rules 254
Device-Specific Rules 255
Relationship-Specific Rules 256

FIG. 2

Universal Data Scaffold
Car 305
Type: car
Make: <string>
Model: <string>
Year: <date>
VIN: <string>
Driven by: <relationship-type>
Owner: <relationship-type>
Photo: <relationship-type>
Universal Data Scaffold
Person 310
Type: person
First Name: <string>
Middle Name: <string>
Last Name: <string>
D.O.B.: <date>
Address: <string>
Phone: <number>
Email: <string>

FIG. 3

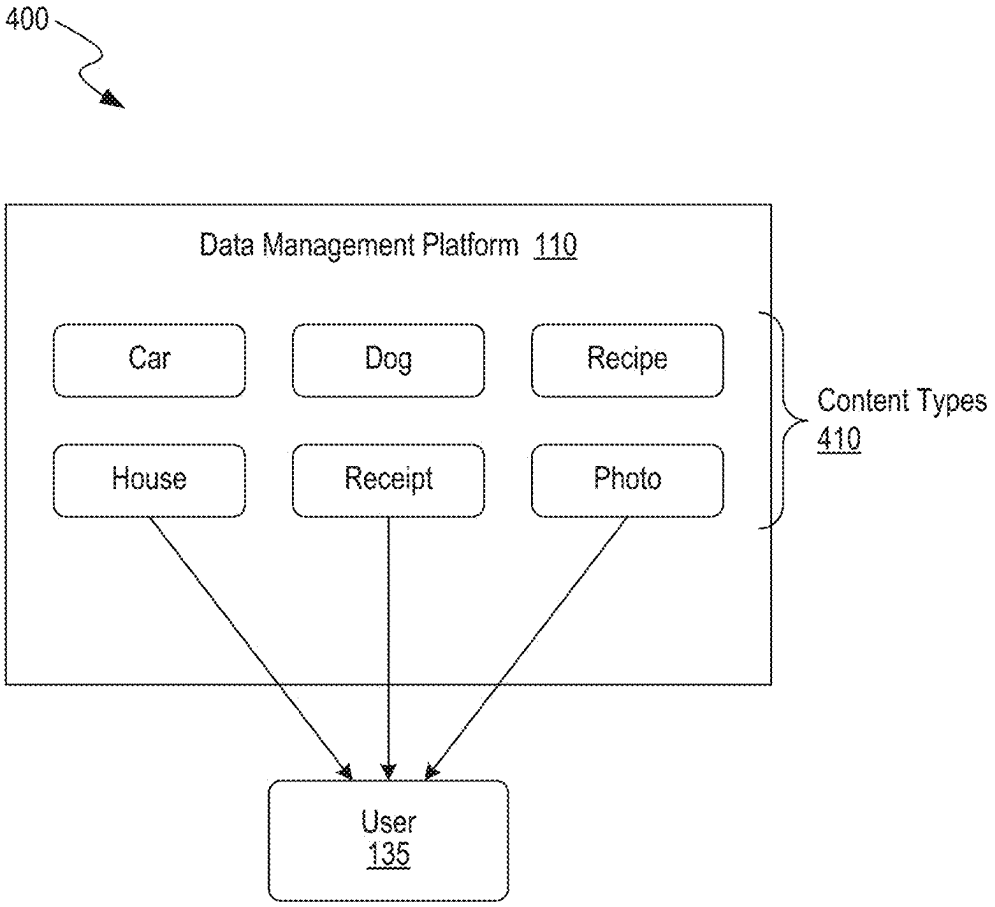

400
Data Management Platform 110
Car
Dog
Recipe
House
Receipt
Photo
Content Types
410
User
135

FIG. 4

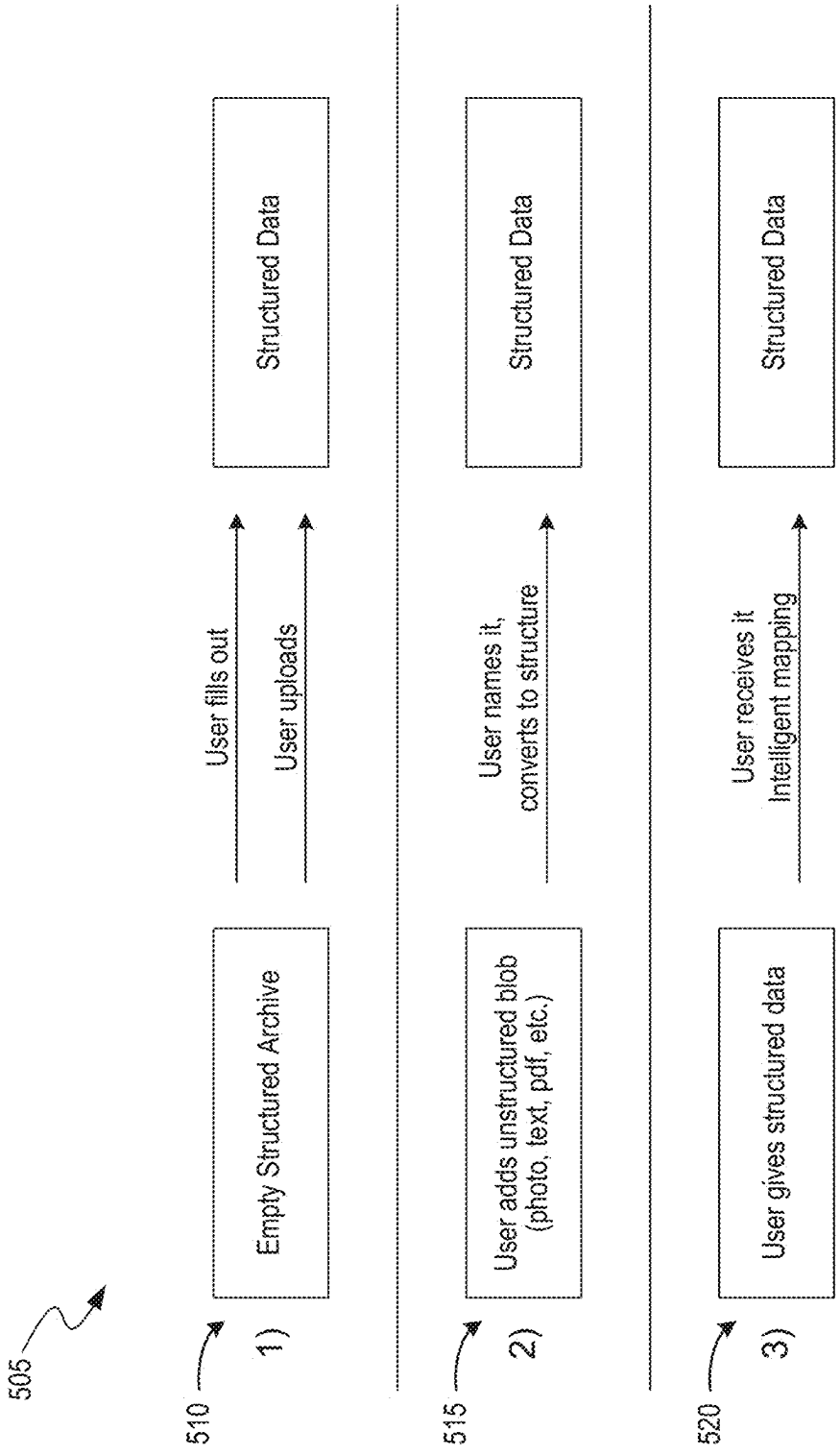

505
510
1)
Empty Structured Archive
User fills out
User uploads
Structured Data
515
2)
User adds unstructured blob (photo, text, pdf, etc.)
User names it, converts to structure
Structured Data
520
3)
User gives structured data
User receives it Intelligent mapping
Structured Data

FIG. 5

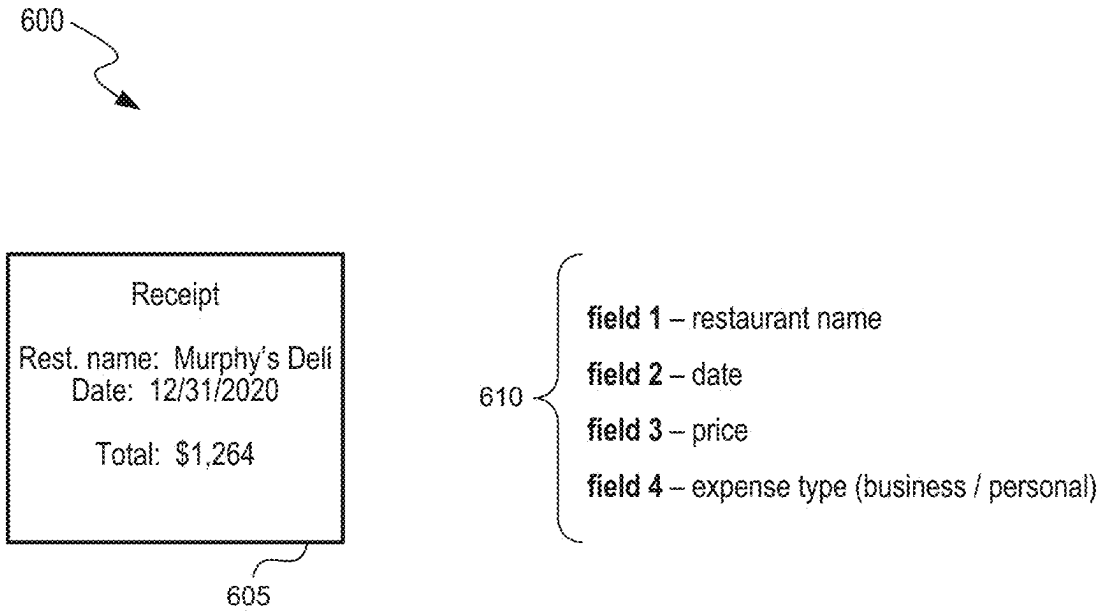

600
Receipt
Rest. name: Murphy's Deli
Date: 12/31/2020
Total: $1,264
605
610
field 1 – restaurant name
field 2 – date
field 3 – price
field 4 – expense type (business / personal)

FIG. 6

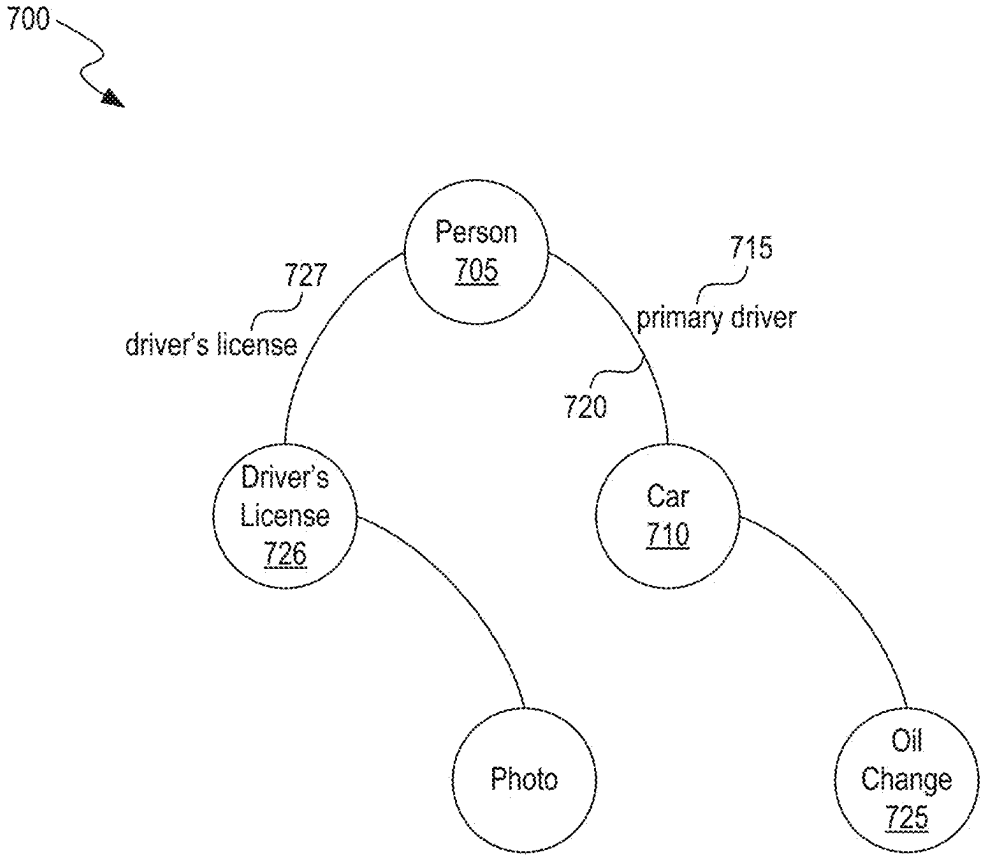

700
Person
705
727
driver's license
715
primary driver
720
Driver's
License
726
Car
710
Photo
Oil
Change
725

FIG. 7A

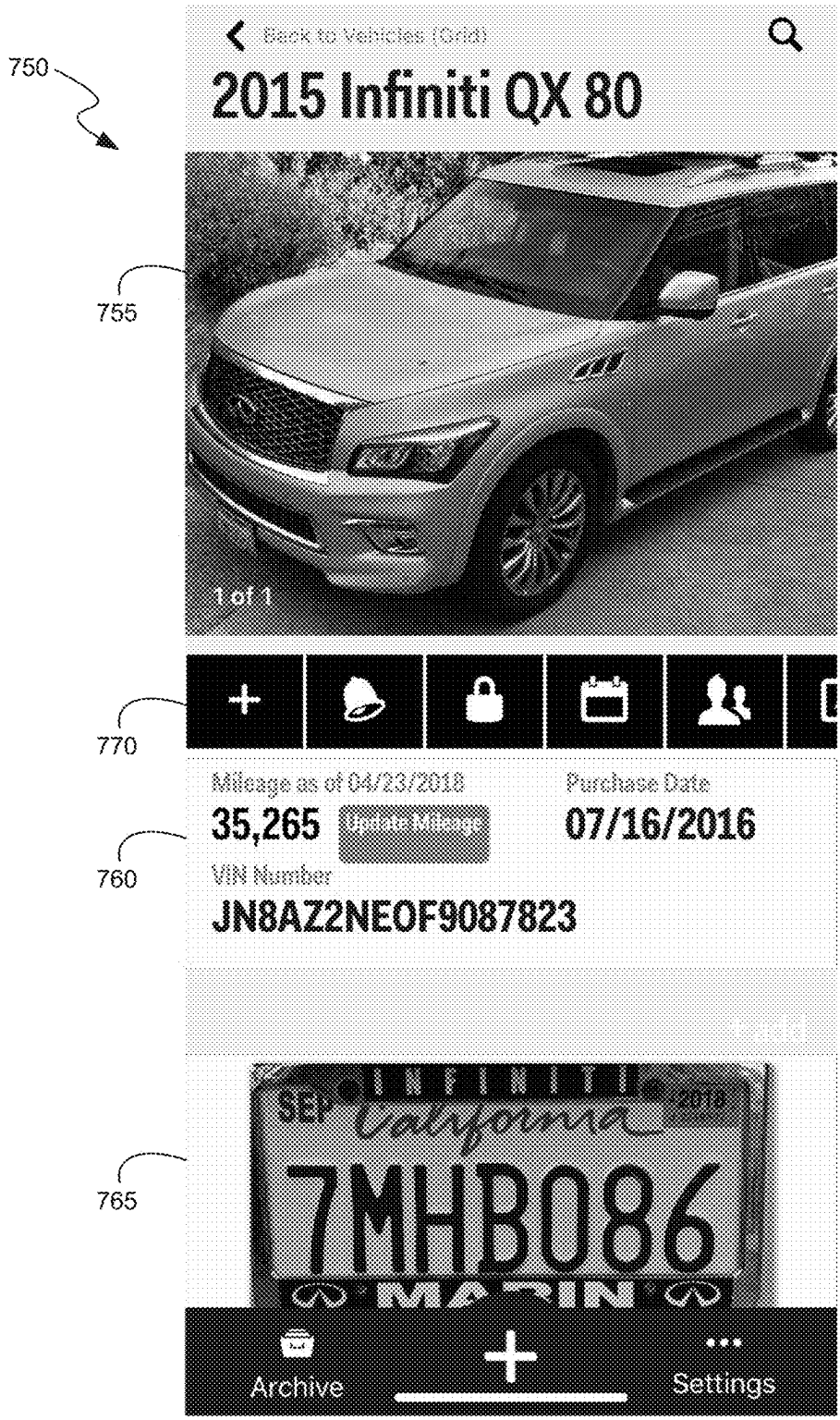

750
755
770
760
765
Back to Vehicles (Grid)
2015 Infiniti QX 80
1 of 1
Mileage as of 04/23/2018
35,265
Update Mileage
Purchase Date
07/16/2016
VIN Number
JN8AZ2NEOF9087823
SEP
California
2018
7MHB086
MARIN
Archive
Settings

FIG. 7B


775
776
777
778
779
2016 Acura MDX
33,430
12/21/2016
23434AHFASDFADF3
Primary Driver
JOHN DOE
4/1/2001
NY
11/30/2008
T460-0777-8323
License Plate
DEC
California
SACRAMENTO

FIG. 7C


780
776
781
782
2016 Acura MDX
License Plate
DEC
California
SACRAMENTO
CA
5/2018
SACRAMENTO
Insurance Policy
STATE FARM
0111-97-03
12/21/2018
$243
$1000

FIG. 7D

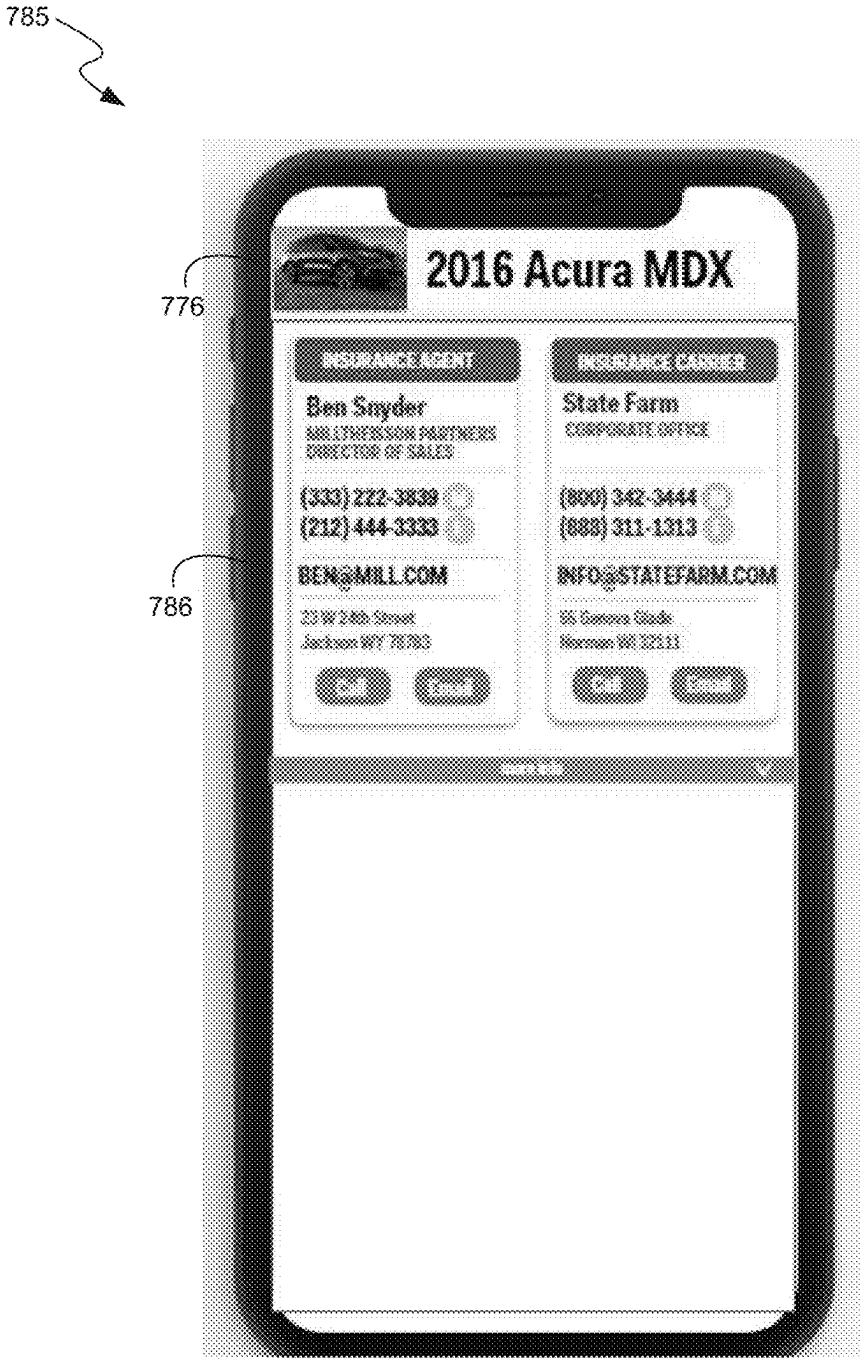

785
776
786
2016 Acura MDX
Ben Snyder
State Farm
(333) 222-3839
(212) 444-3333
(800) 342-3444
(888) 311-1313
BEN@MILL.COM
INFO@STATEFARM.COM

FIG. 7E

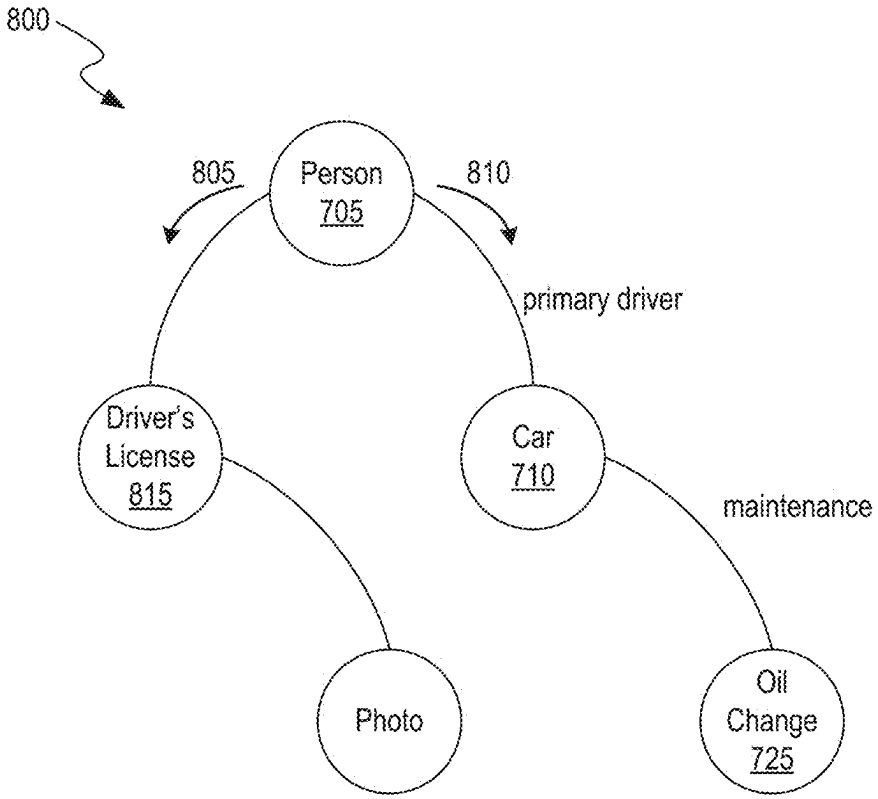

800
805
Person
705
810
primary driver
Driver's
License
815
Car
710
maintenance
Photo
Oil
Change
725

FIG. 8

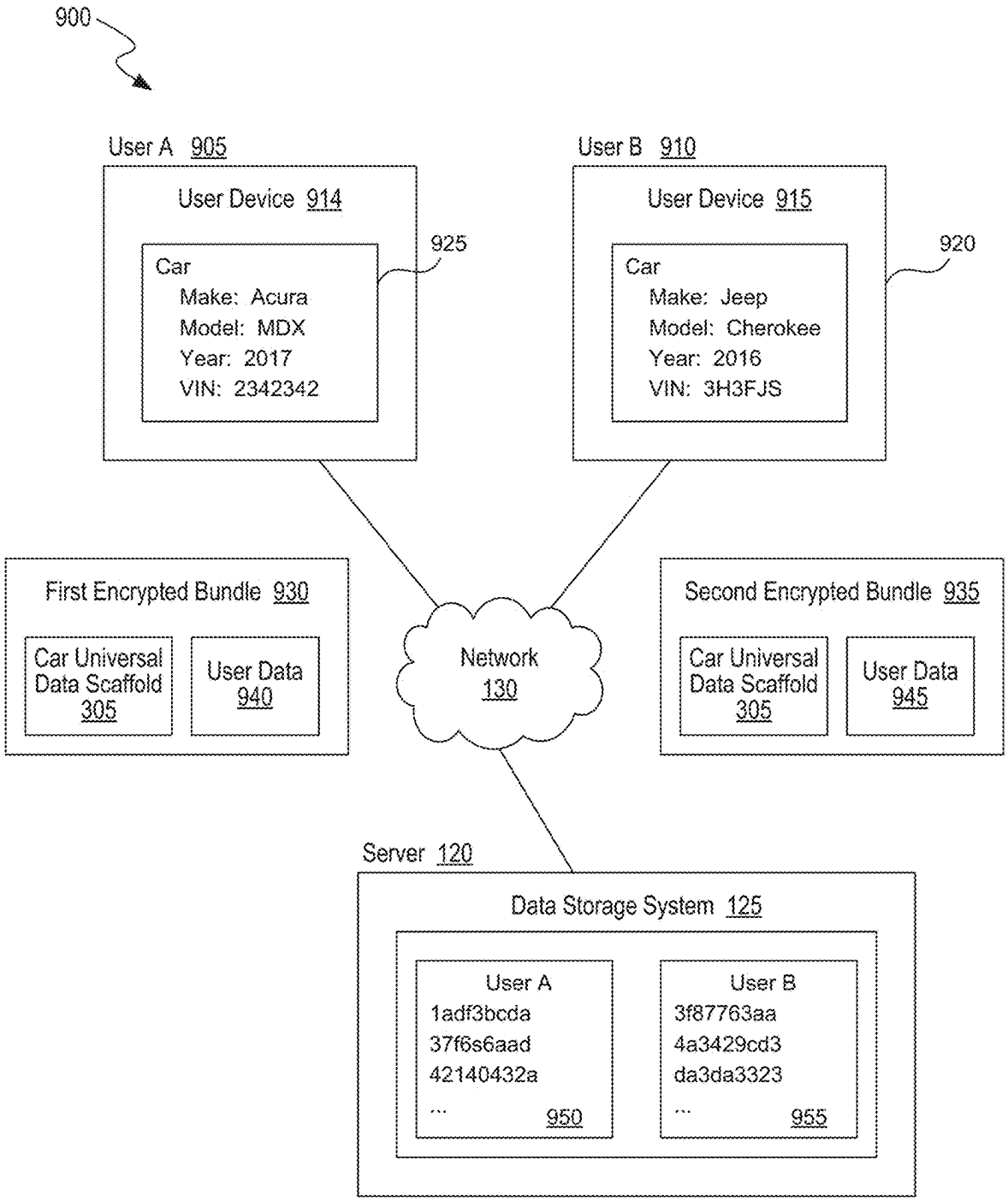

900
User A 905
User Device 914
Car
Make: Acura
Model: MDX
Year: 2017
VIN: 2342342
925
User B 910
User Device 915
Car
Make: Jeep
Model: Cherokee
Year: 2016
VIN: 3H3FJS
920
First Encrypted Bundle 930
Car Universal Data Scaffold 305
User Data 940
Network 130
Second Encrypted Bundle 935
Car Universal Data Scaffold 305
User Data 945
Server 120
Data Storage System 125
User A
1adf3bcda
37f6s6aad
42140432a
...
950
User B
3f87763aa
4a3429cd3
da3da3323
...
955

FIG. 9

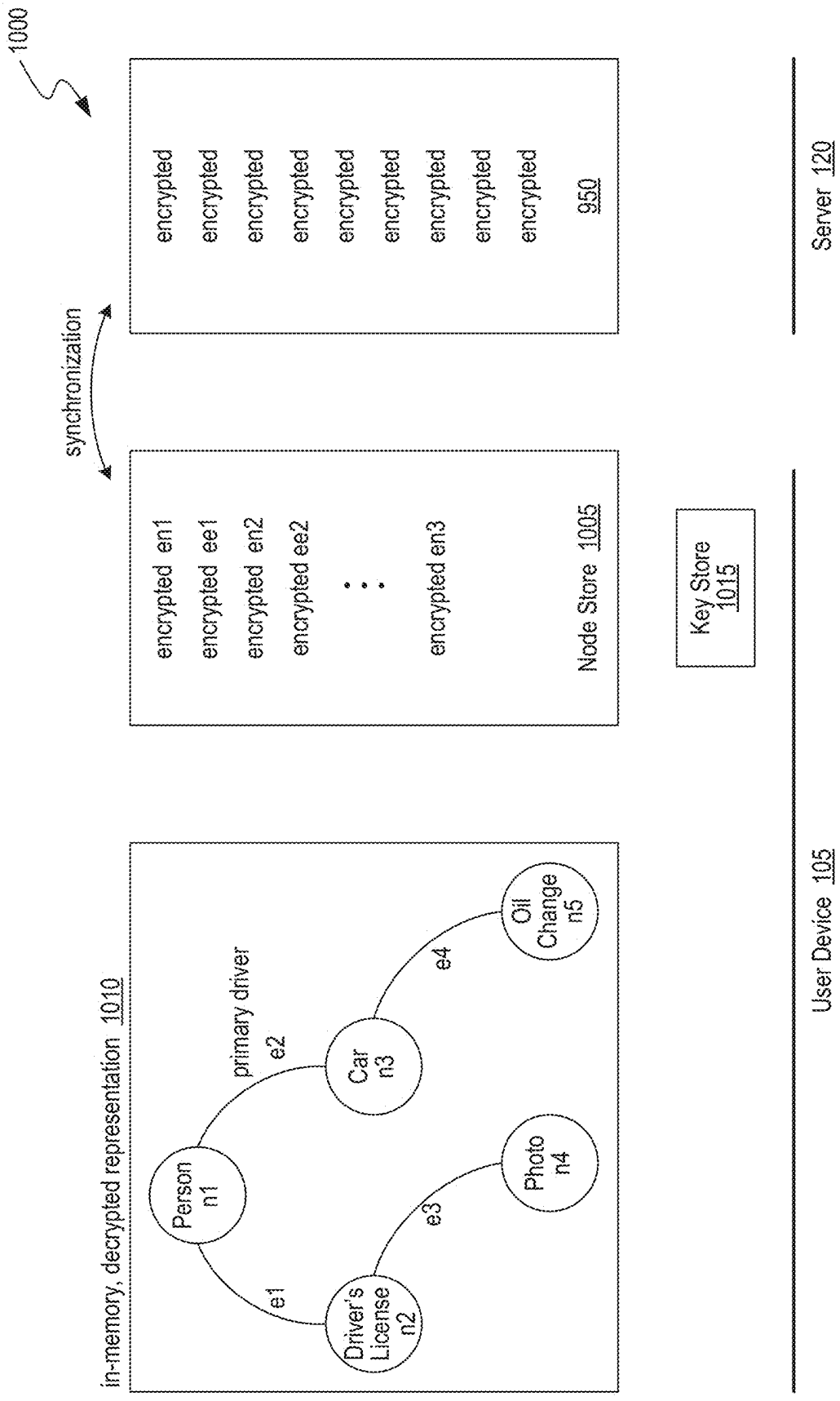

1000
synchronization
encrypted
encrypted
encrypted
encrypted
encrypted
encrypted
encrypted
encrypted
encrypted
950
Server 120
encrypted en1
encrypted ee1
encrypted en2
encrypted ee2
encrypted en3
Node Store 1005
Key Store 1015
in-memory, decrypted representation 1010
Person n1
primary driver
e2
Car n3
e4
Oil Change n5
e1
Driver's License n2
e3
Photo n4
User Device 105

FIG. 10

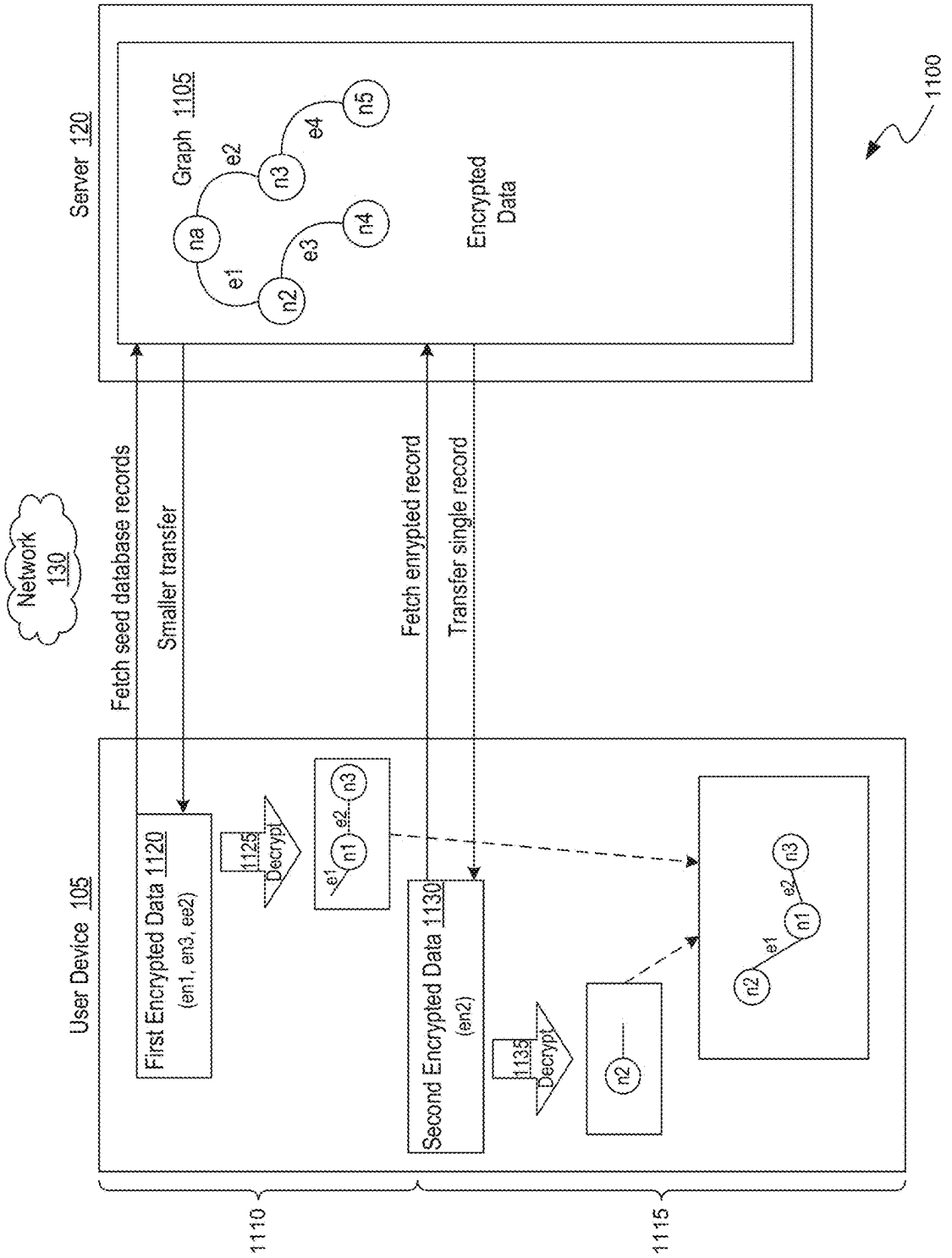

Server 120
Graph 1105
na
n2
n3
n4
n5
e1
e2
e3
e4
Encrypted Data
1100
Network 130
Fetch seed database records
Smaller transfer
Fetch enrypted record
Transfer single record
User Device 105
First Encrypted Data 1120
(en1, en3, ee2)
1125
Decrypt
Second Encrypted Data 1130
(en2)
1135
Decrypt
1110
1115

FIG. 11

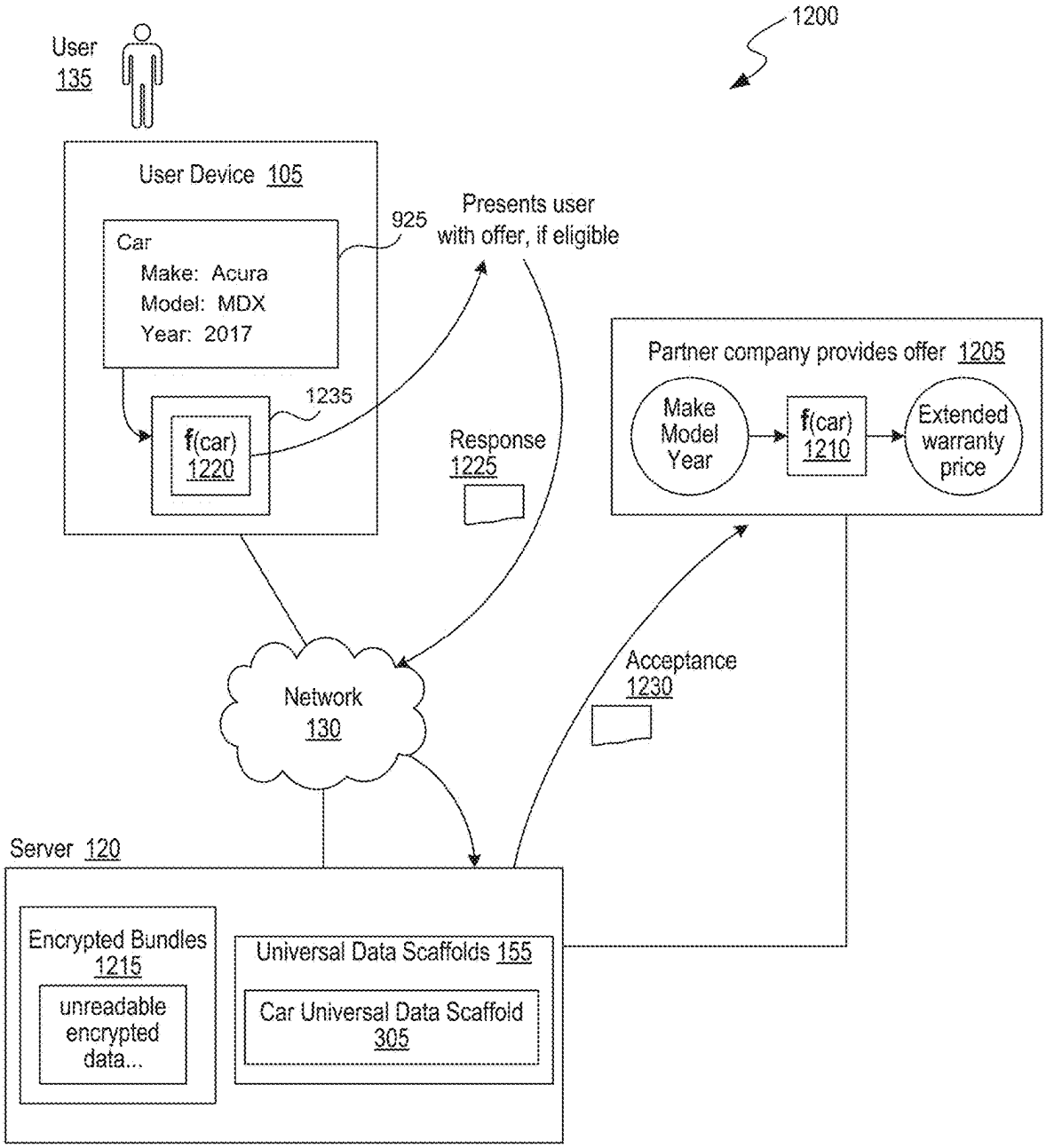

1200
User
135
User Device 105
Car
Make: Acura
Model: MDX
Year: 2017
925
Presents user with offer, if eligible
1235
f(car)
1220
Response
1225
Partner company provides offer 1205
Make
Model
Year
f(car)
1210
Extended warranty price
Network
130
Acceptance
1230
Server 120
Encrypted Bundles
1215
unreadable encrypted data...
Universal Data Scaffolds 155
Car Universal Data Scaffold
305

FIG. 12

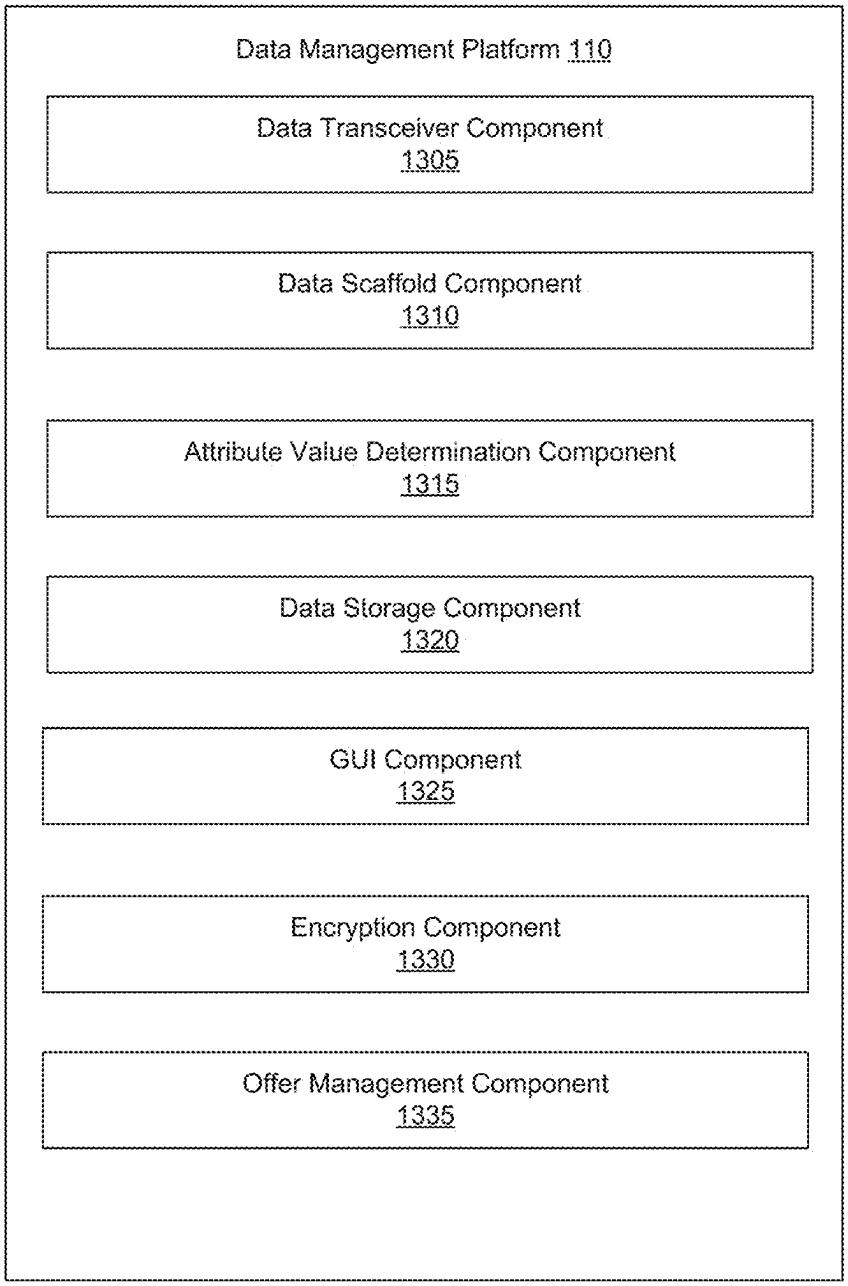

Data Management Platform 110
Data Transceiver Component
1305
Data Scaffold Component
1310
Attribute Value Determination Component
1315
Data Storage Component
1320
GUI Component
1325
Encryption Component
1330
Offer Management Component
1335

FIG. 13

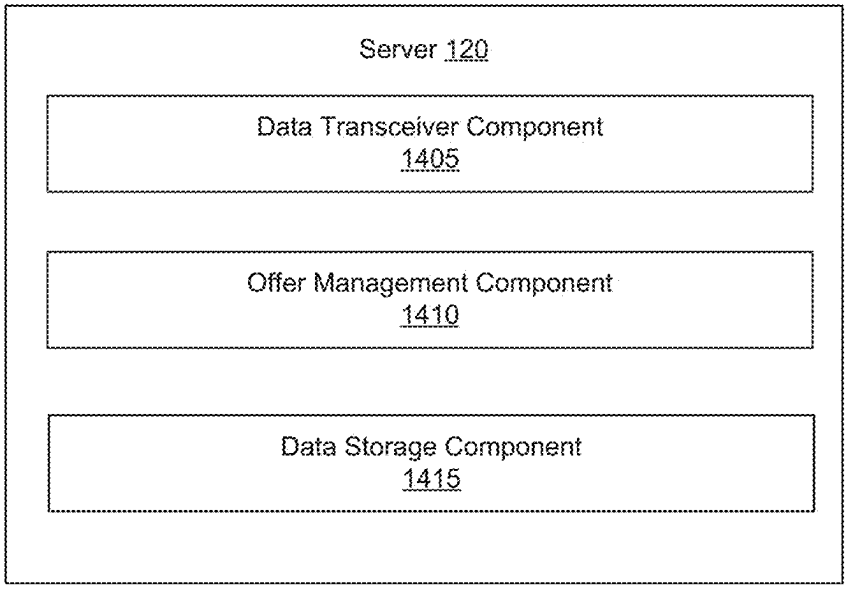

Server 120
Data Transceiver Component
1405
Offer Management Component
1410
Data Storage Component
1415

FIG. 14

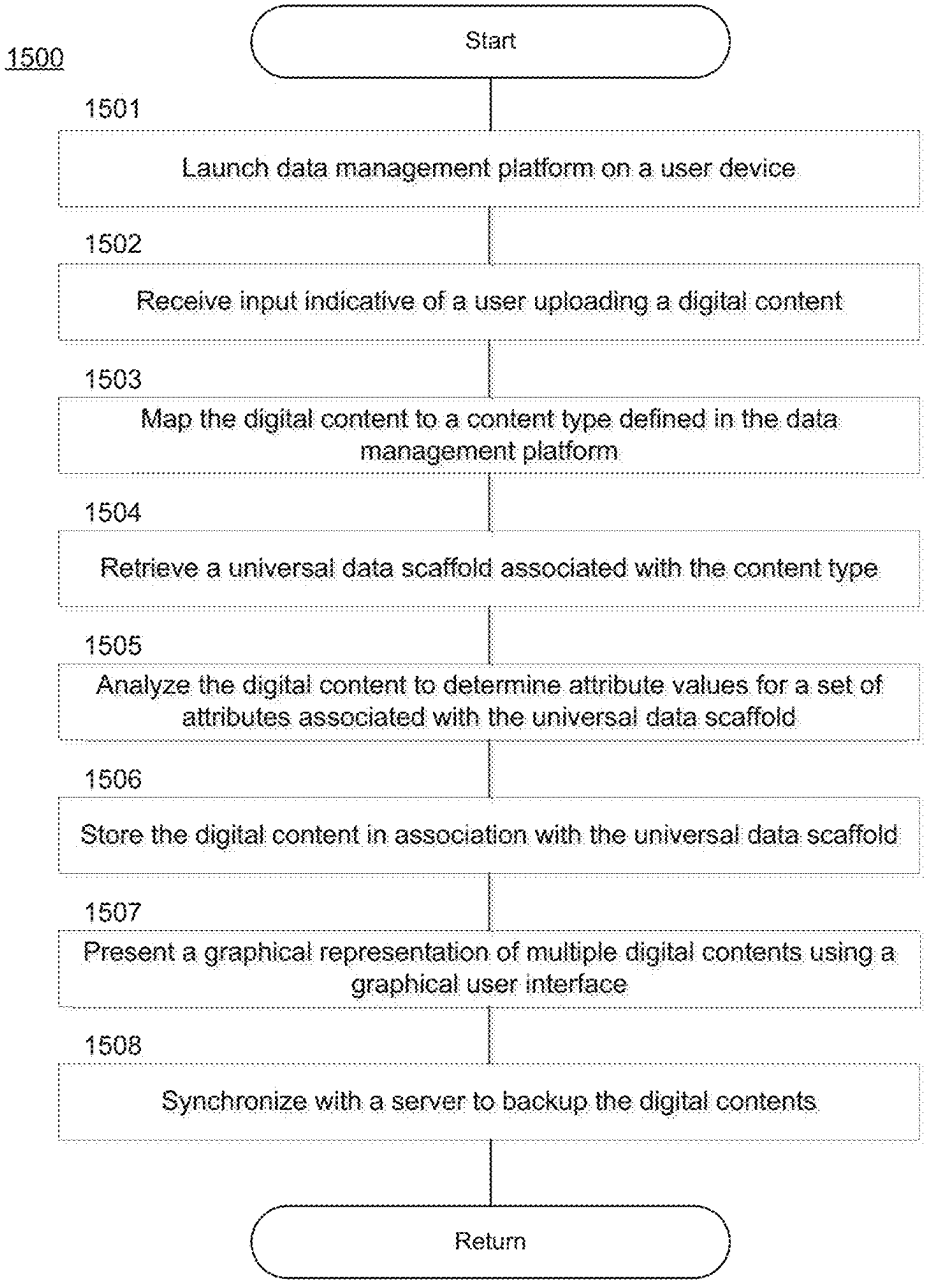

1500
Start
1501
Launch data management platform on a user device
1502
Receive input indicative of a user uploading a digital content
1503
Map the digital content to a content type defined in the data management platform
1504
Retrieve a universal data scaffold associated with the content type
1505
Analyze the digital content to determine attribute values for a set of attributes associated with the universal data scaffold
1506
Store the digital content in association with the universal data scaffold
1507
Present a graphical representation of multiple digital contents using a graphical user interface
1508
Synchronize with a server to backup the digital contents
Return

FIG. 15

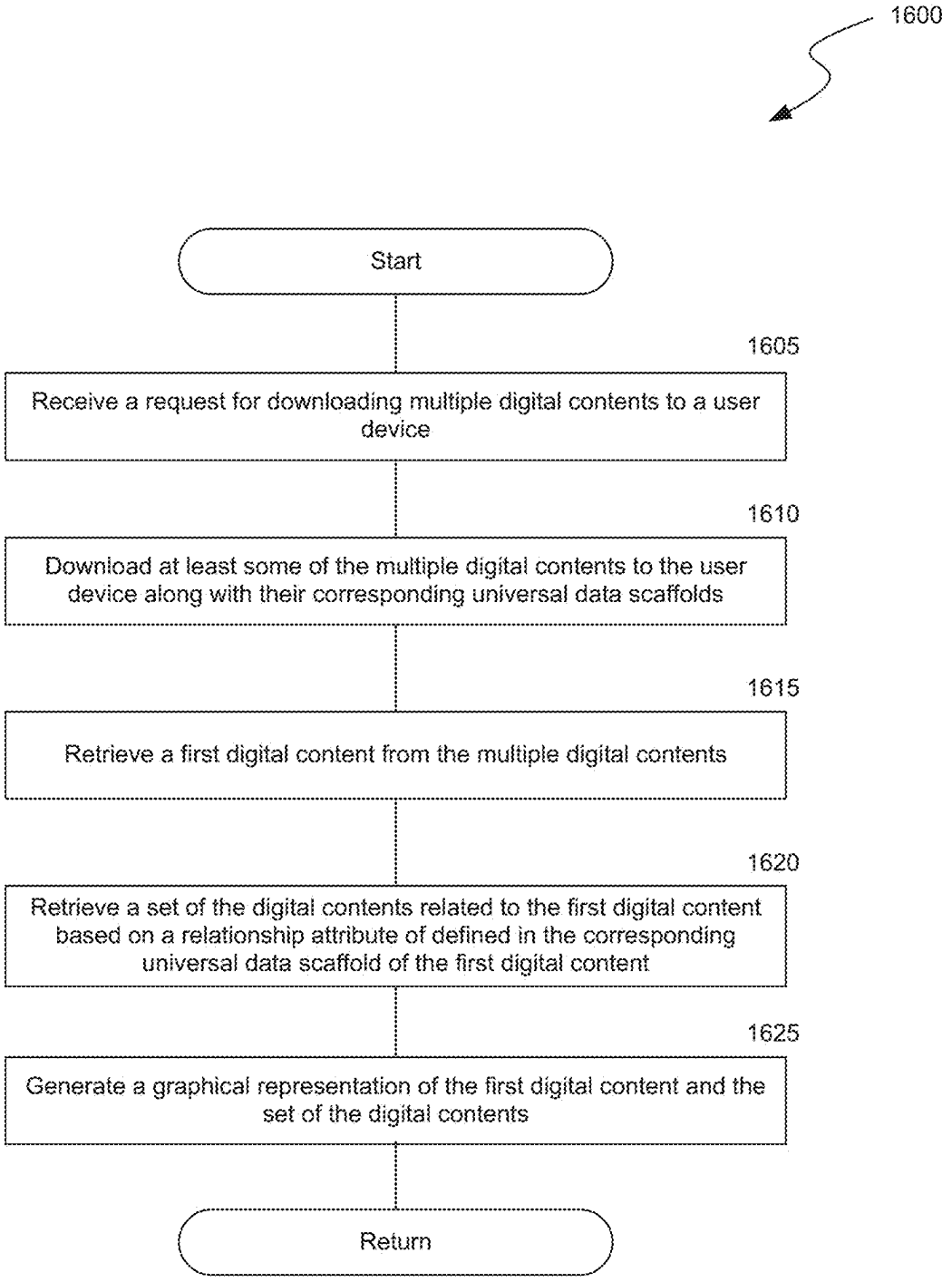

1600
Start
1605
Receive a request for downloading multiple digital contents to a user device
1610
Download at least some of the multiple digital contents to the user device along with their corresponding universal data scaffolds
1615
Retrieve a first digital content from the multiple digital contents
1620
Retrieve a set of the digital contents related to the first digital content based on a relationship attribute of defined in the corresponding universal data scaffold of the first digital content
1625
Generate a graphical representation of the first digital content and the set of the digital contents
Return

FIG. 16

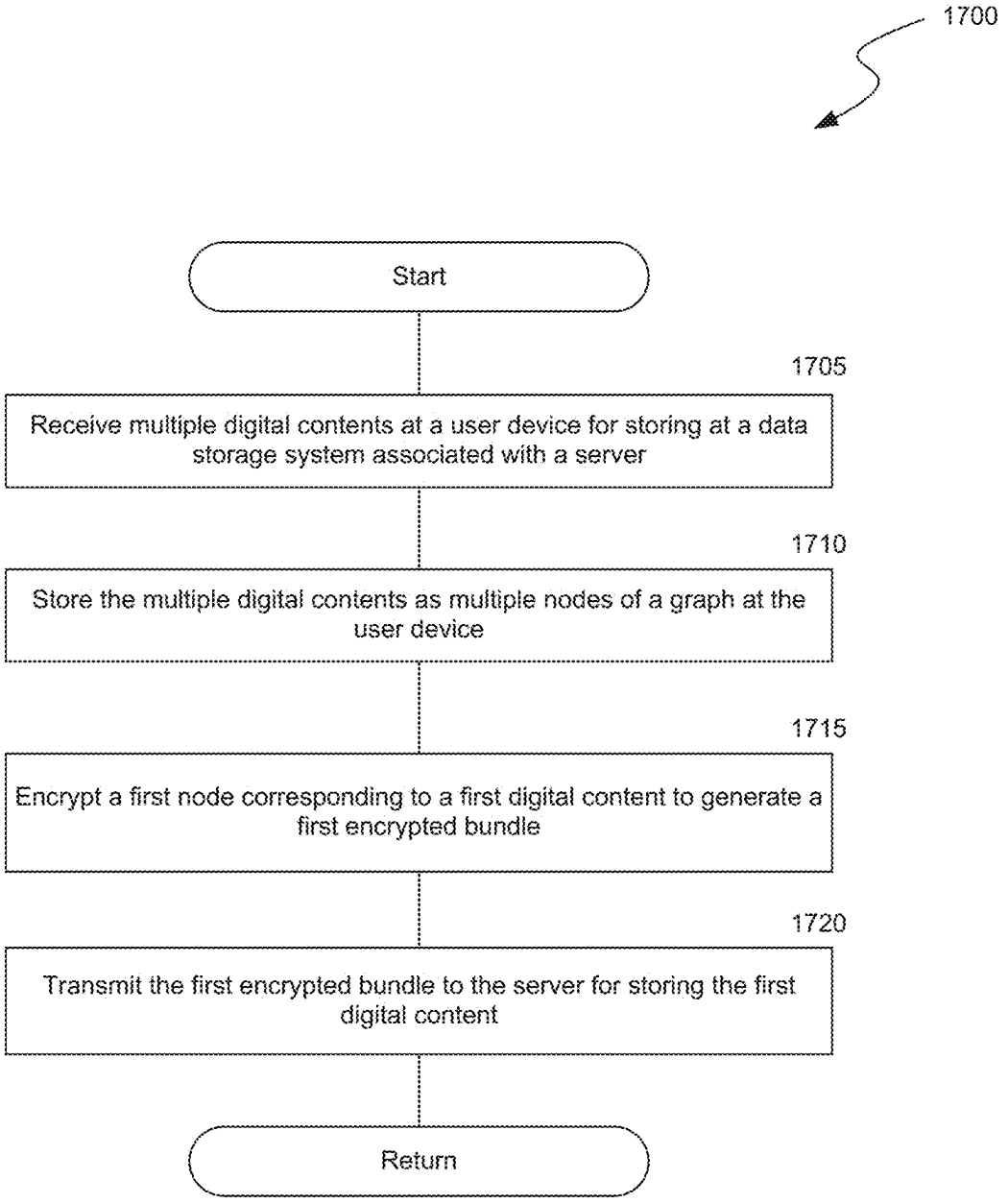

1700
Start
1705
Receive multiple digital contents at a user device for storing at a data storage system associated with a server
1710
Store the multiple digital contents as multiple nodes of a graph at the user device
1715
Encrypt a first node corresponding to a first digital content to generate a first encrypted bundle
1720
Transmit the first encrypted bundle to the server for storing the first digital content
Return

FIG. 17

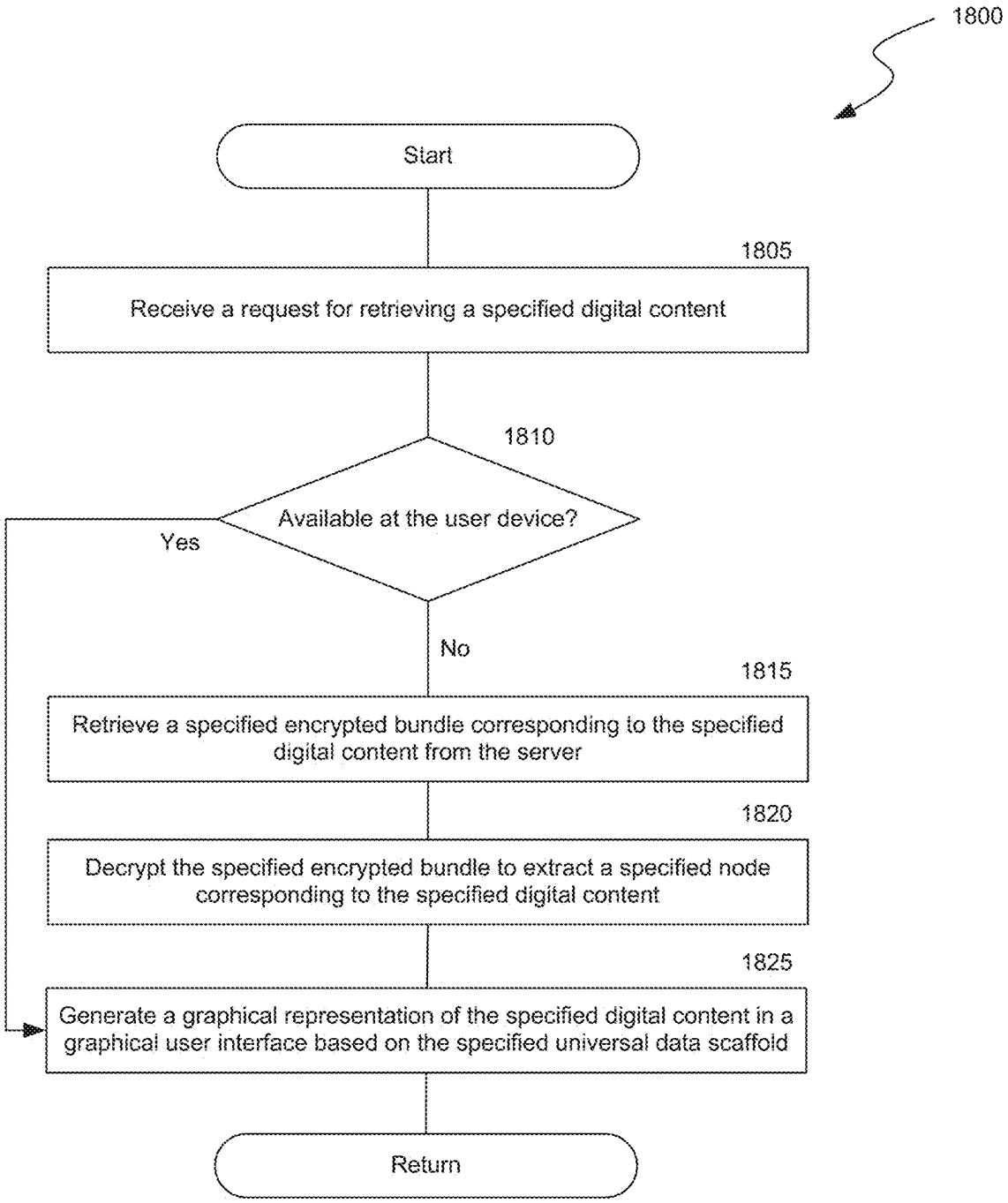

1800
Start
1805
Receive a request for retrieving a specified digital content
1810
Available at the user device?
Yes
No
1815
Retrieve a specified encrypted bundle corresponding to the specified digital content from the server
1820
Decrypt the specified encrypted bundle to extract a specified node corresponding to the specified digital content
1825
Generate a graphical representation of the specified digital content in a graphical user interface based on the specified universal data scaffold
Return

FIG. 18

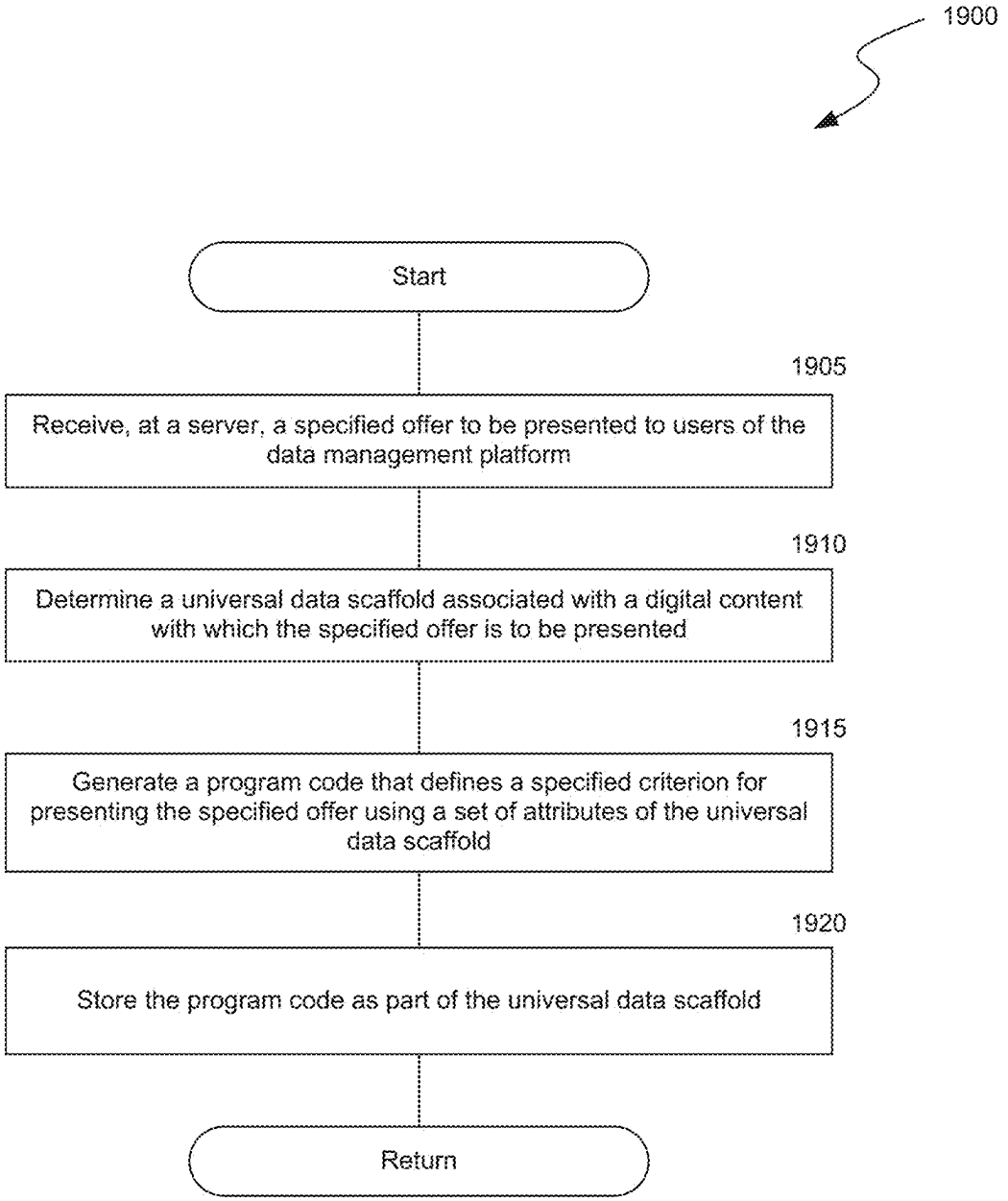

1900
Start
1905
Receive, at a server, a specified offer to be presented to users of the data management platform
1910
Determine a universal data scaffold associated with a digital content with which the specified offer is to be presented
1915
Generate a program code that defines a specified criterion for presenting the specified offer using a set of attributes of the universal data scaffold
1920
Store the program code as part of the universal data scaffold
Return

FIG. 19

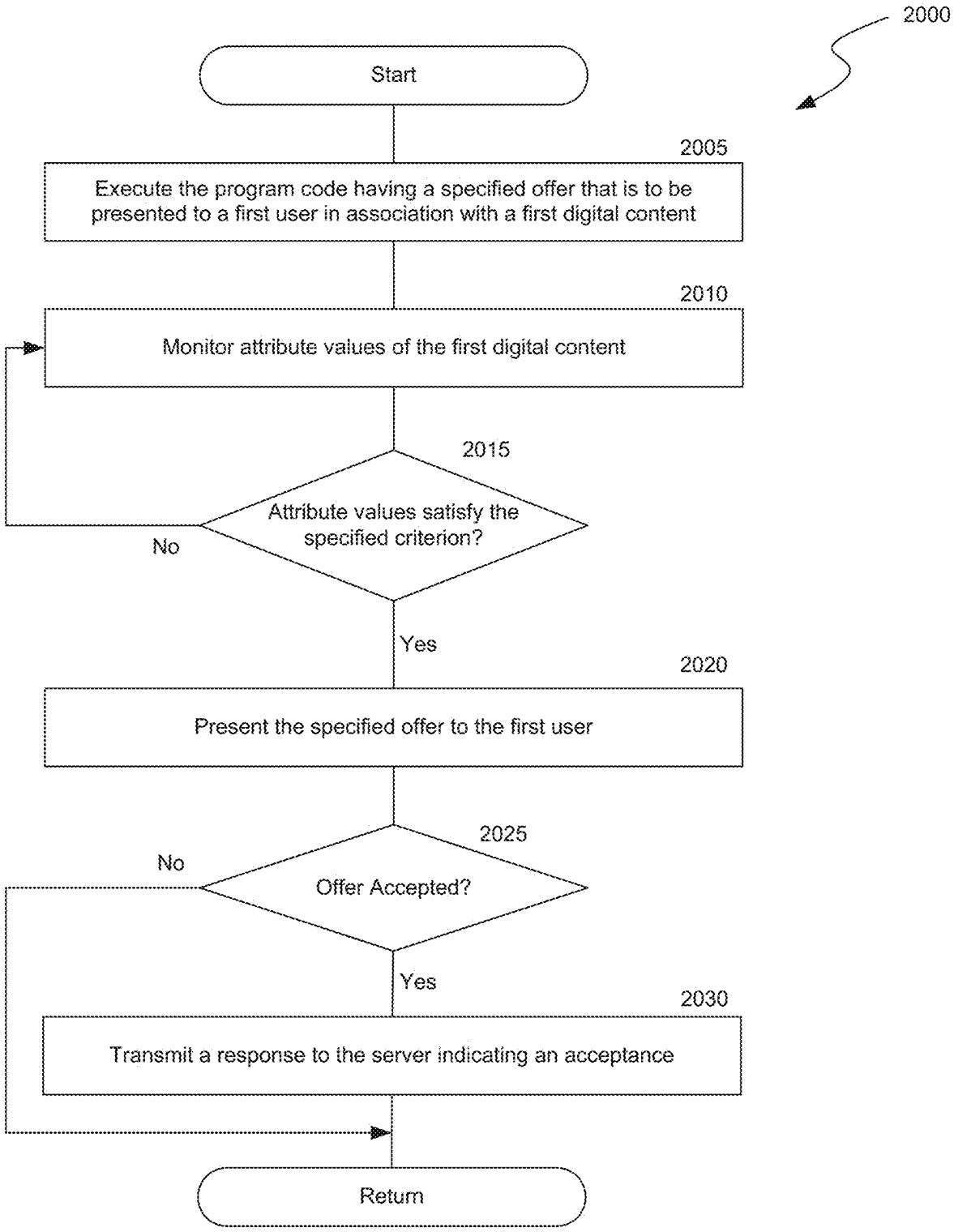

2000
Start
2005
Execute the program code having a specified offer that is to be presented to a first user in association with a first digital content
2010
Monitor attribute values of the first digital content
2015
Attribute values satisfy the specified criterion?
No
Yes
2020
Present the specified offer to the first user
2025
Offer Accepted?
No
Yes
2030
Transmit a response to the server indicating an acceptance
Return

FIG. 20

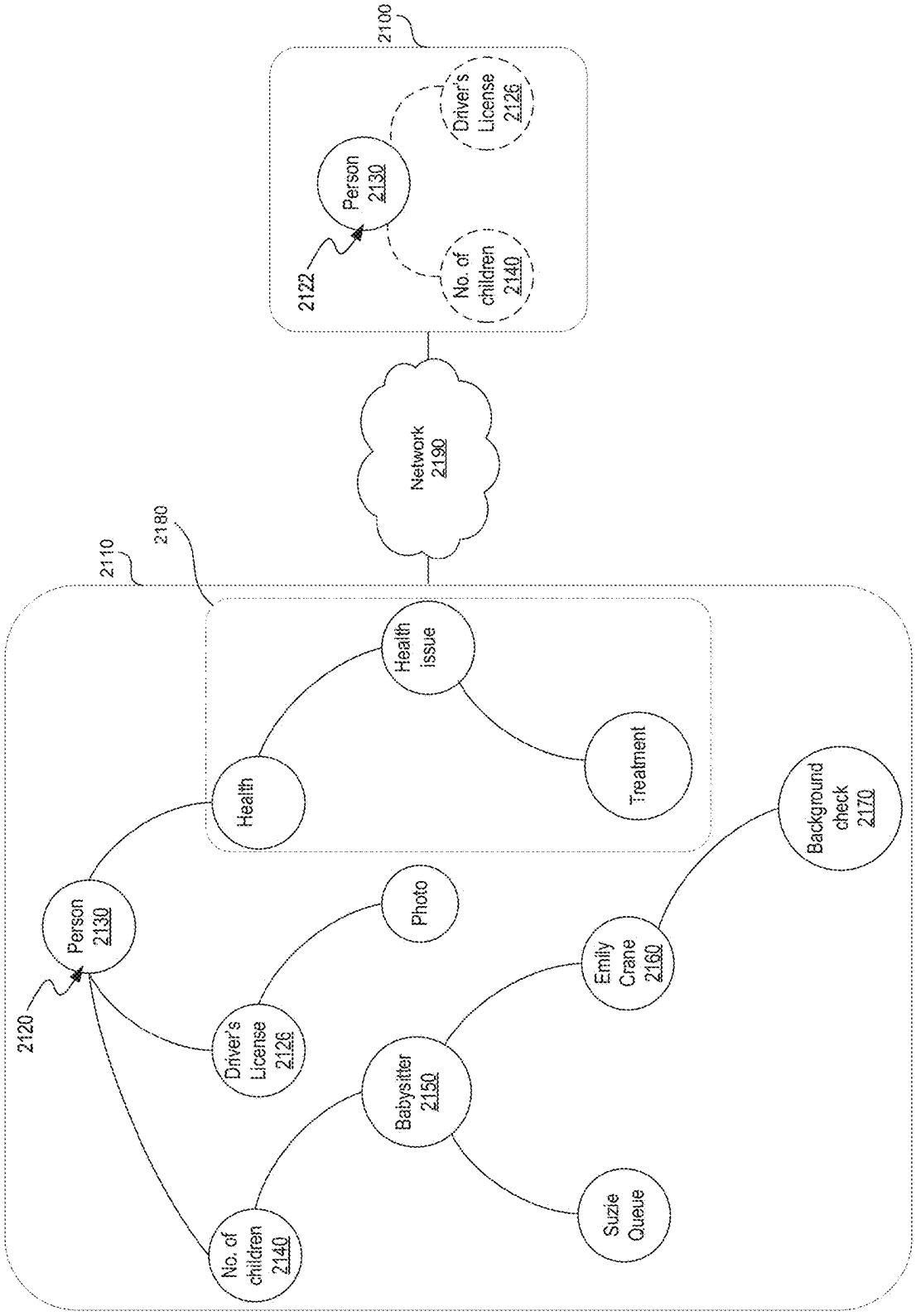

2100
Person 2130
Driver's License 2126
No. of children 2140
2122
Network 2190
2110
2180
Health issue
Health
Treatment
Person 2130
Photo
Driver's License 2126
Emily Crane 2160
Background check 2170
Babysitter 2150
Suzie Queue
No. of children 2140
2120

FIG. 21

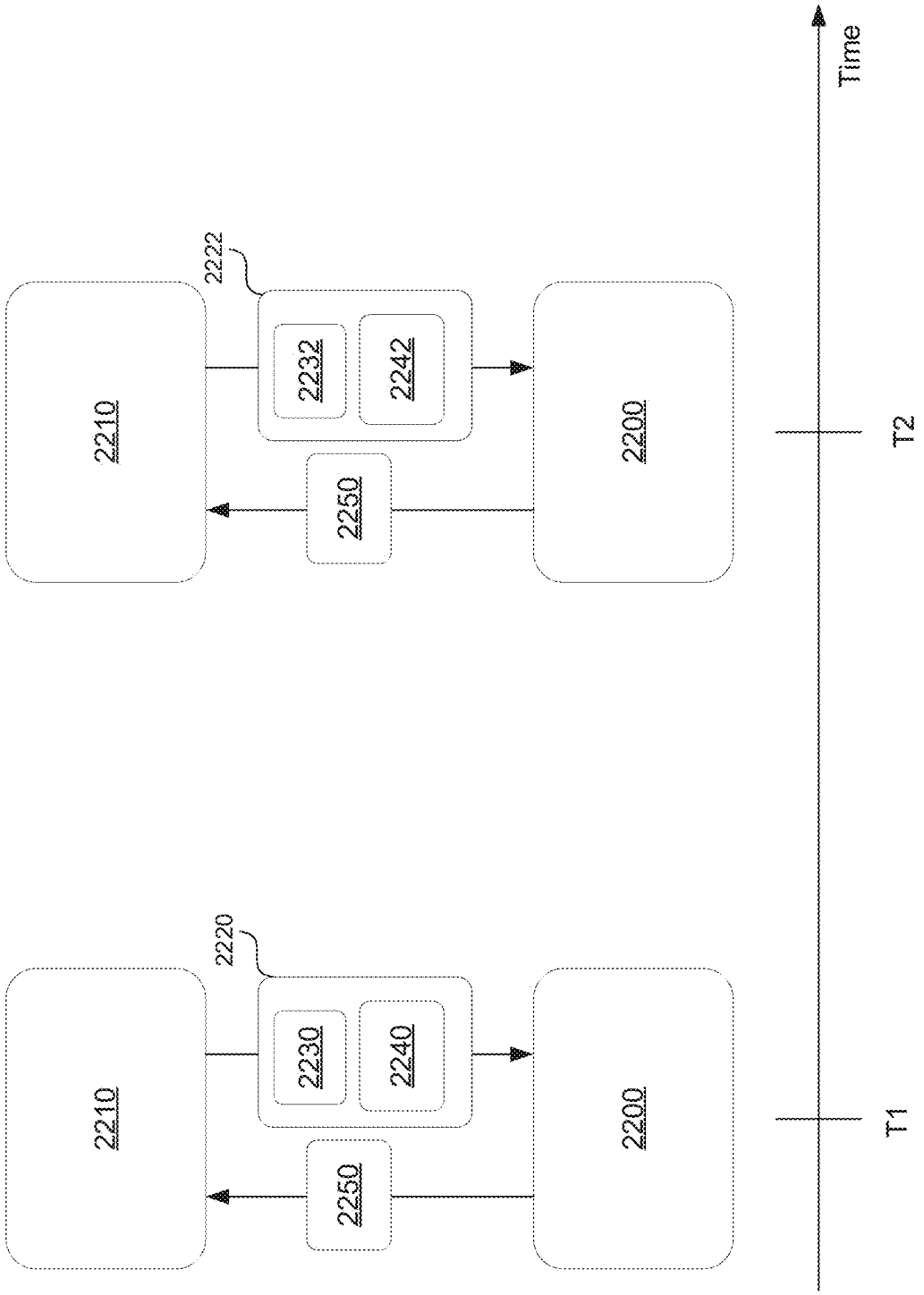

Time
T1
T2
2210
2220
2230
2240
2250
2200
2210
2222
2232
2242
2250
2200

FIG. 22

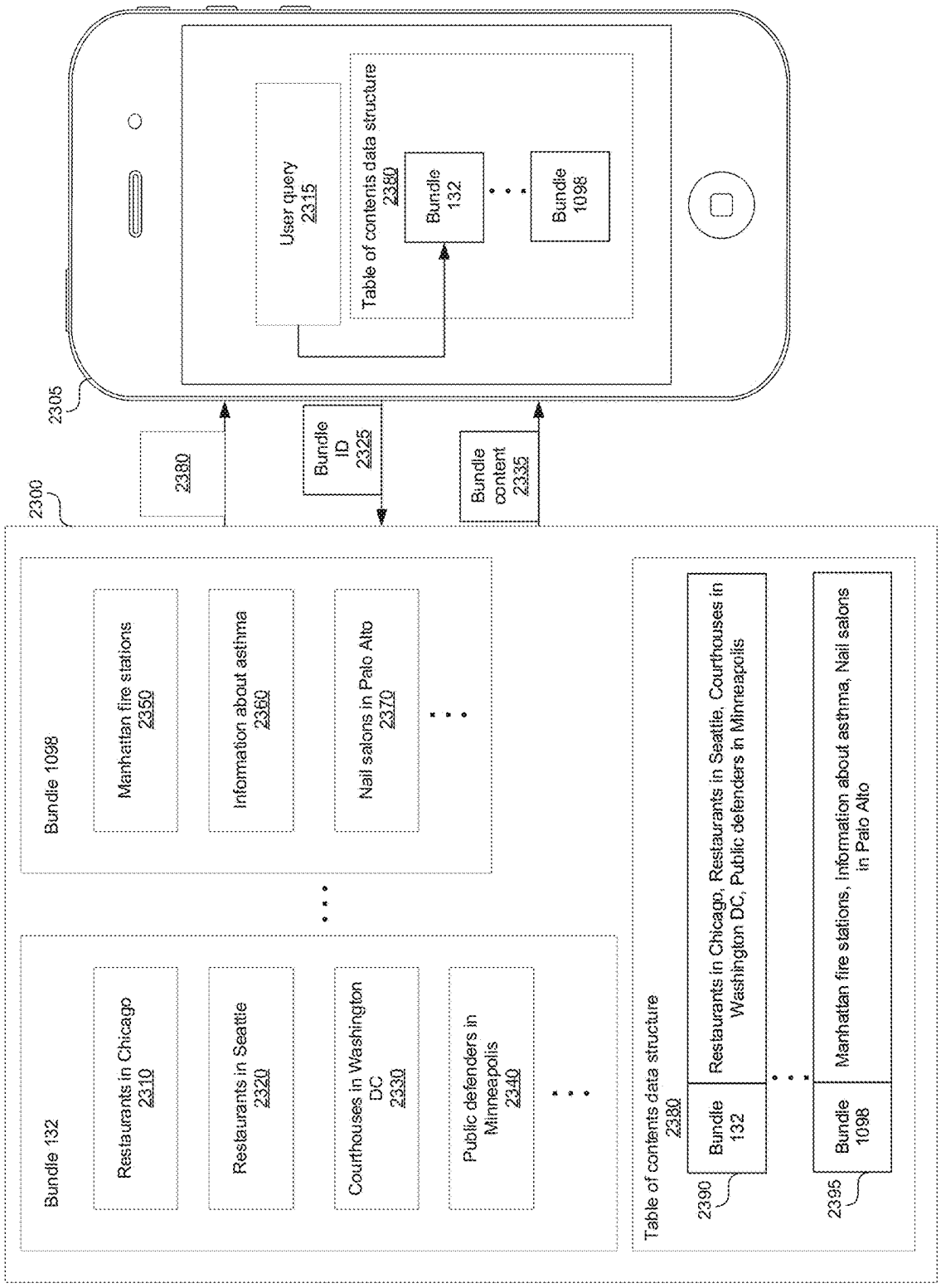

2305
User query 2315
Table of contents data structure 2380
Bundle 132
Bundle 1098
2300
2380
Bundle ID 2325
Bundle content 2335
Bundle 1098
Manhattan fire stations 2350
Information about asthma 2360
Nail salons in Palo Alto 2370
Bundle 132
Restaurants in Chicago 2310
Restaurants in Seattle 2320
Courthouses in Washington DC 2330
Public defenders in Minneapolis 2340
Table of contents data structure 2380
2390
Bundle 132
Restaurants in Chicago, Restaurants in Seattle, Courthouses in Washington DC, Public defenders in Minneapolis
2395
Bundle 1098
Manhattan fire stations, Information about asthma, Nail salons in Palo Alto

FIG. 23

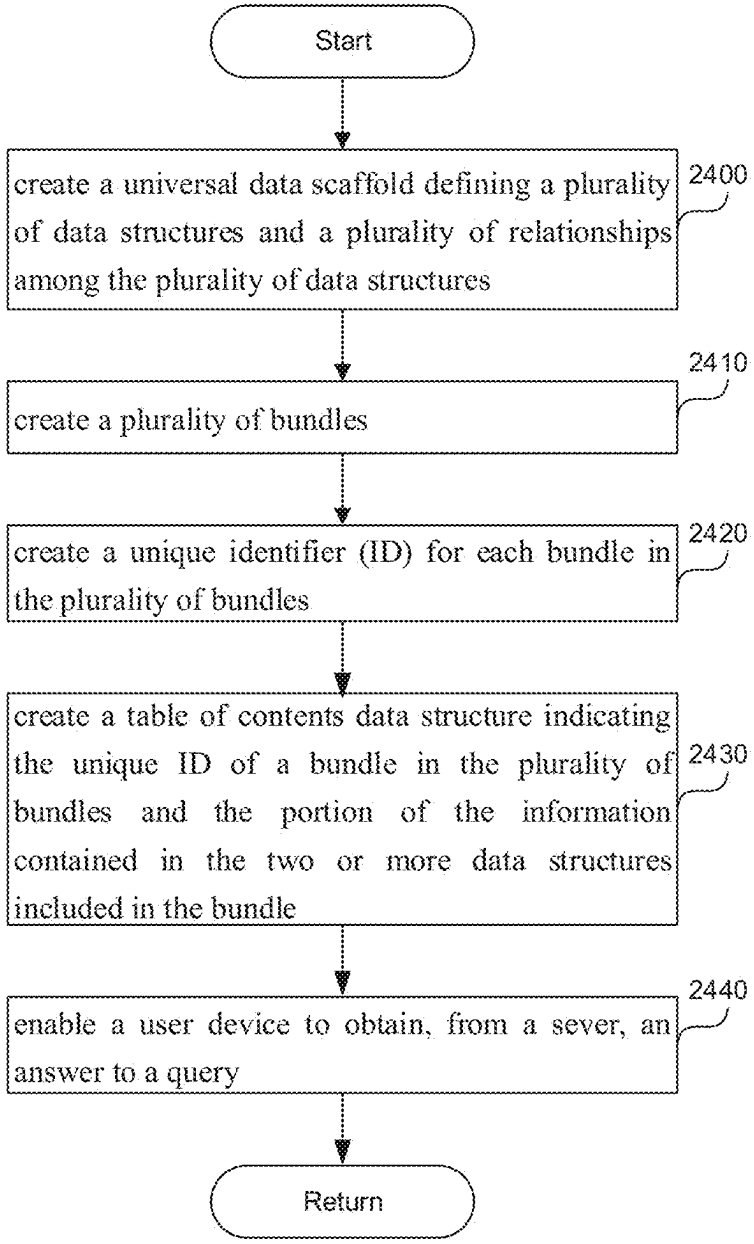

Start
create a universal data scaffold defining a plurality of data structures and a plurality of relationships among the plurality of data structures
2400
create a plurality of bundles
2410
create a unique identifier (ID) for each bundle in the plurality of bundles
2420
create a table of contents data structure indicating the unique ID of a bundle in the plurality of bundles and the portion of the information contained in the two or more data structures included in the bundle
2430
enable a user device to obtain, from a sever, an answer to a query
2440
Return

FIG. 24

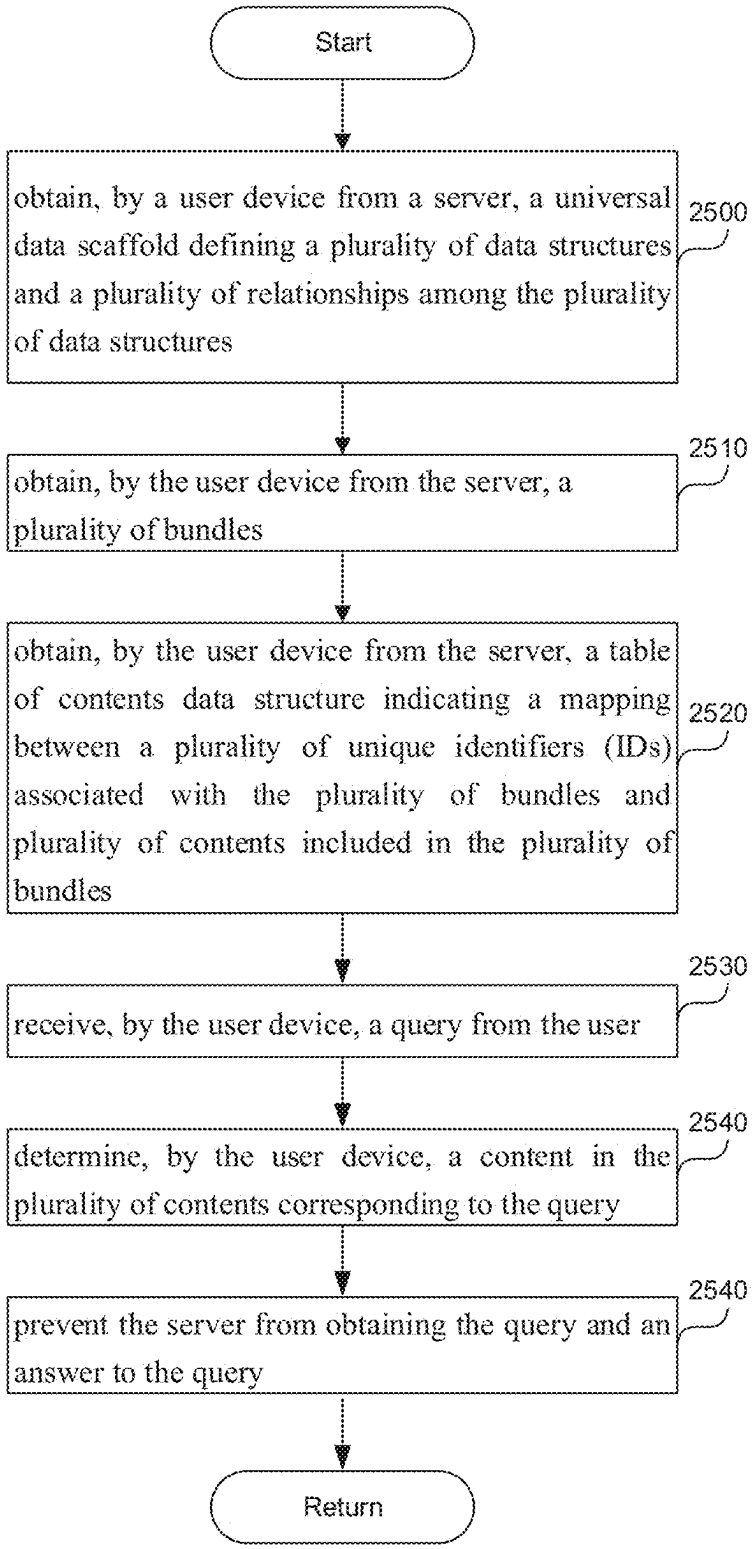

Start
obtain, by a user device from a server, a universal data scaffold defining a plurality of data structures and a plurality of relationships among the plurality of data structures
2500
obtain, by the user device from the server, a plurality of bundles
2510
obtain, by the user device from the server, a table of contents data structure indicating a mapping between a plurality of unique identifiers (IDs) associated with the plurality of bundles and plurality of contents included in the plurality of bundles
2520
receive, by the user device, a query from the user
2530
determine, by the user device, a content in the plurality of contents corresponding to the query
2540
prevent the server from obtaining the query and an answer to the query
2540
Return

FIG. 25

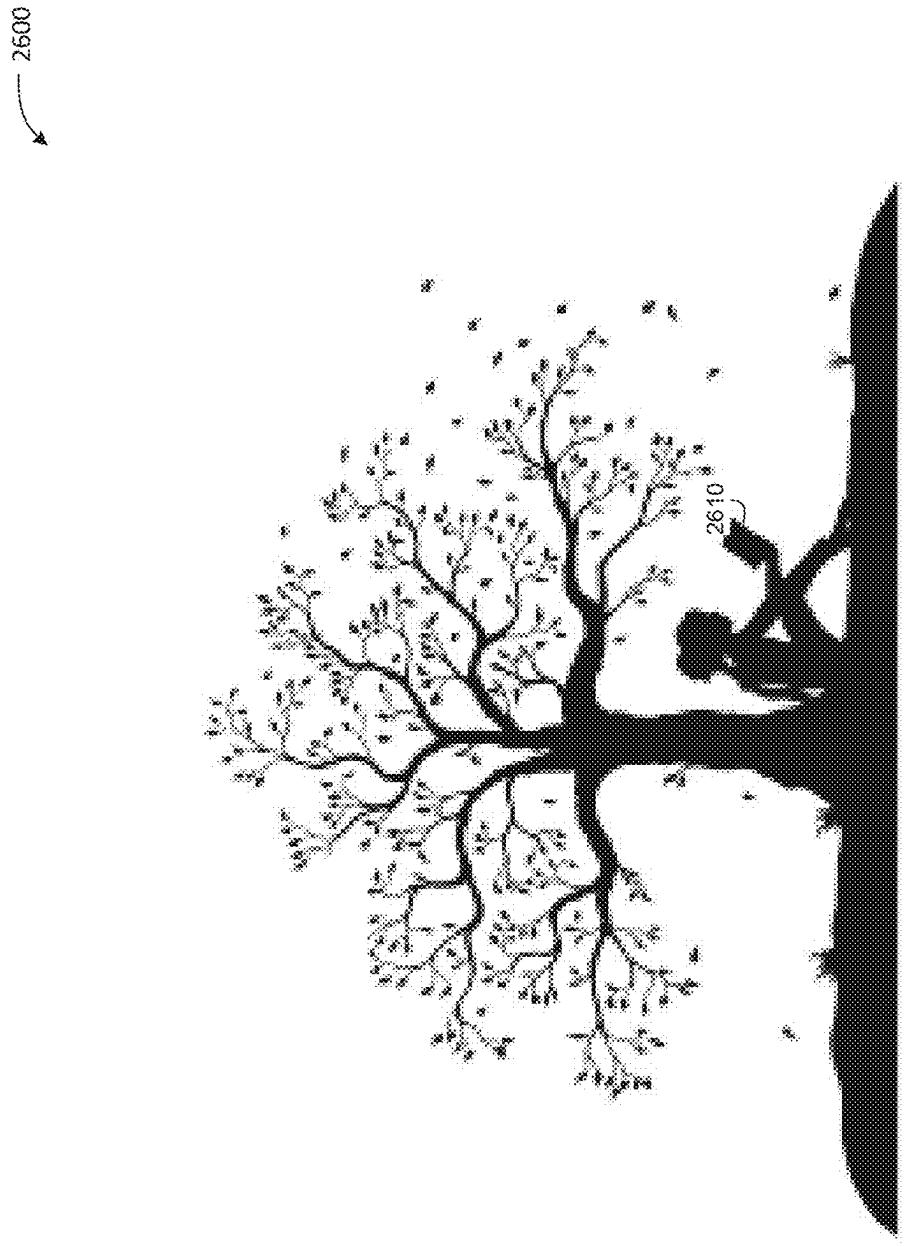


FIG. 26

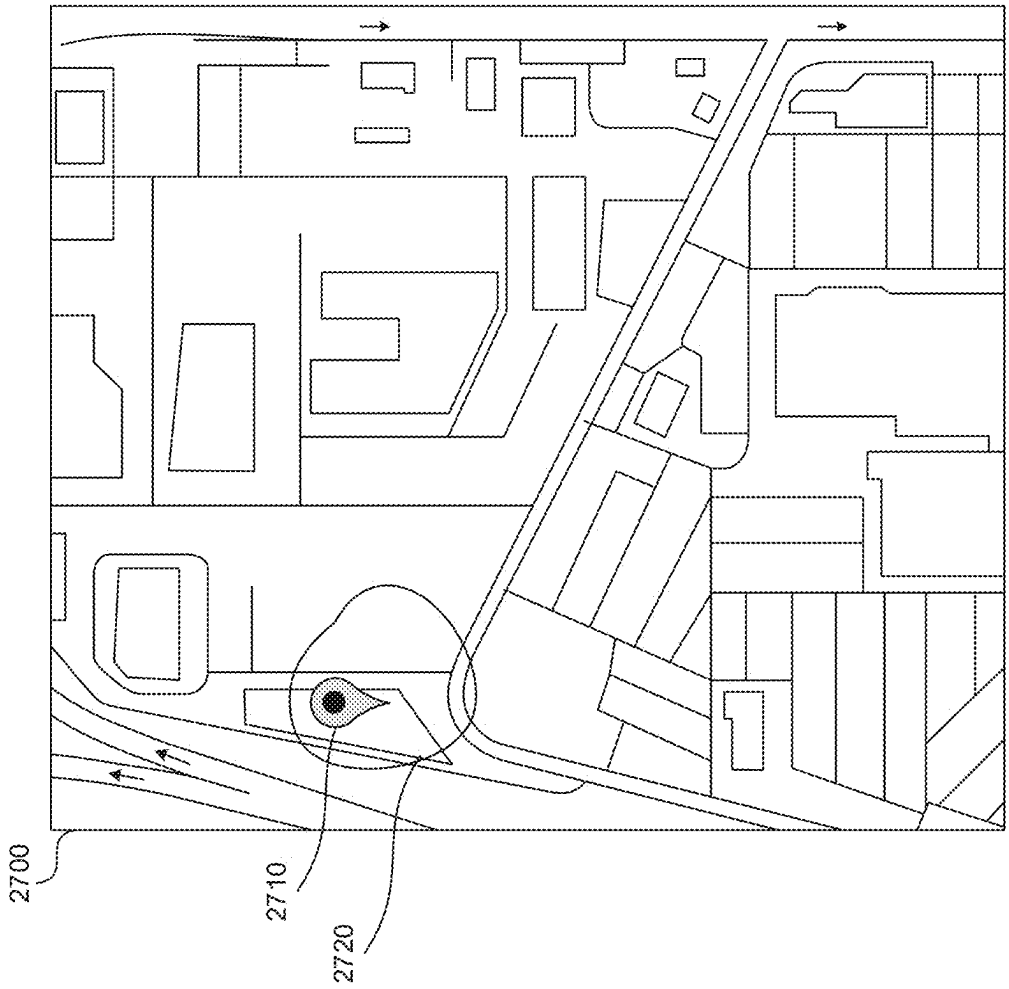


FIG. 27

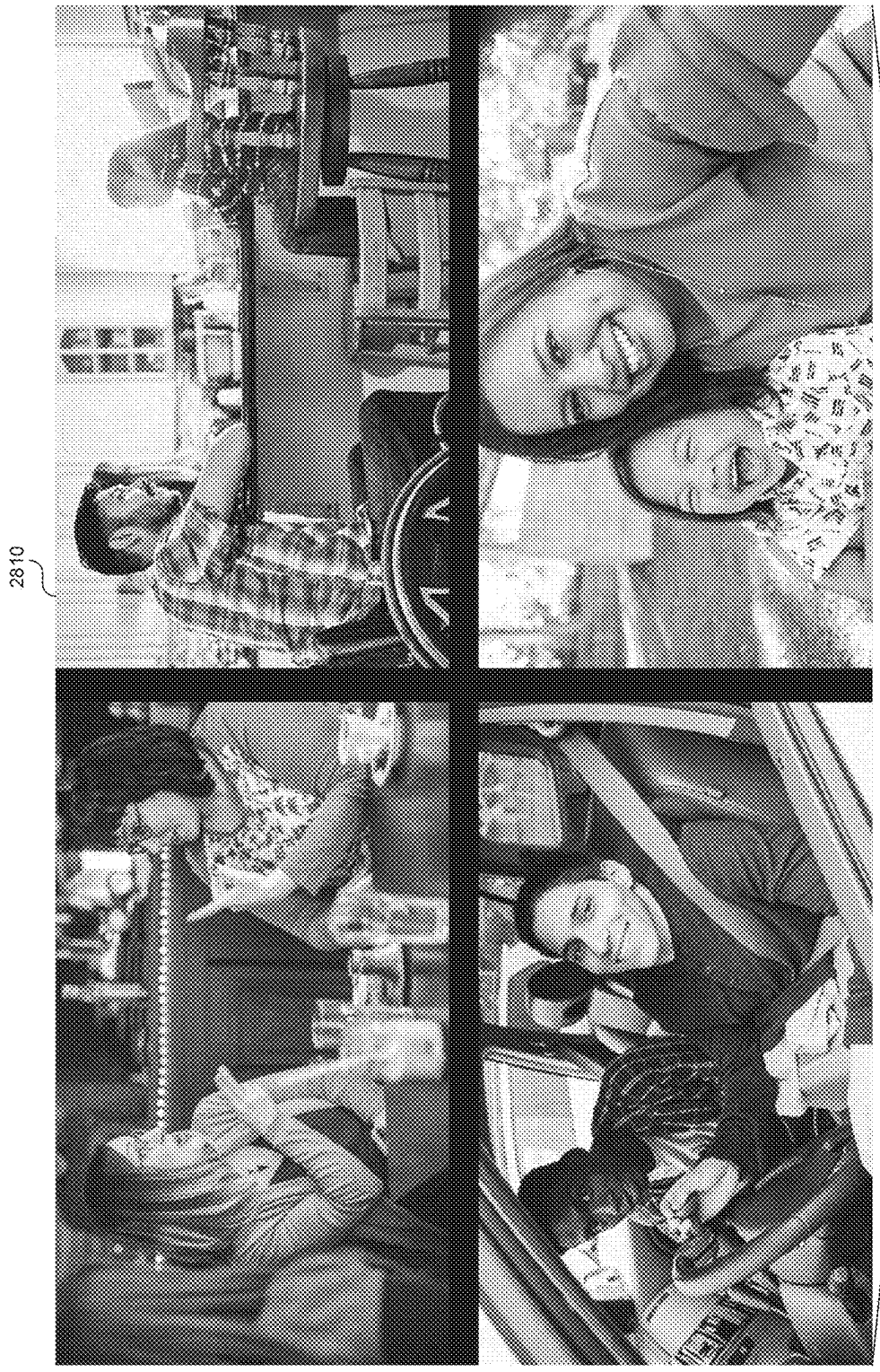


FIG. 28

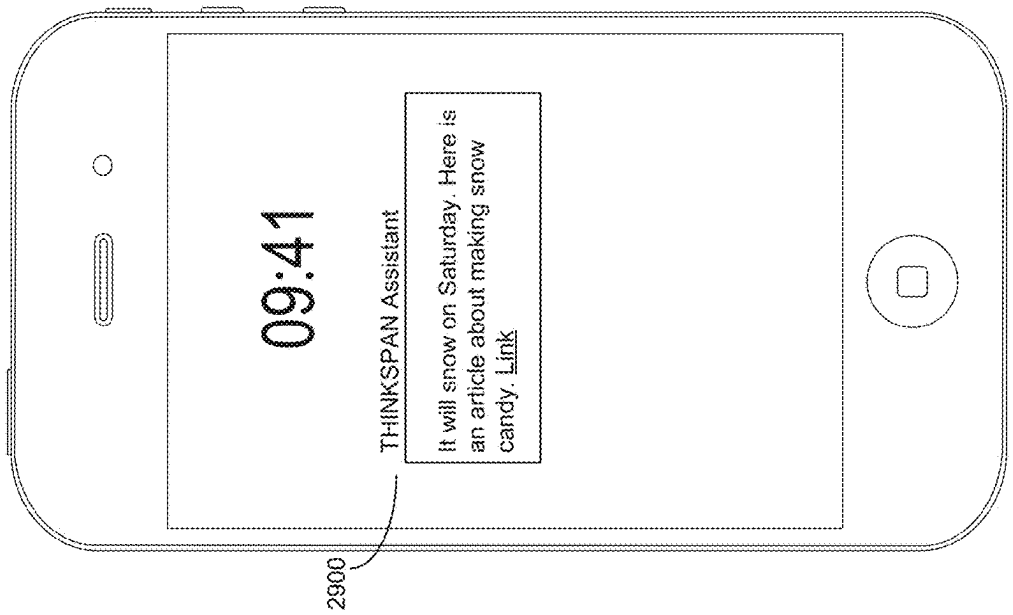

09:41
THINKSPAN Assistant
It will snow on Saturday. Here is an article about making snow candy. Link
2900

FIG. 29

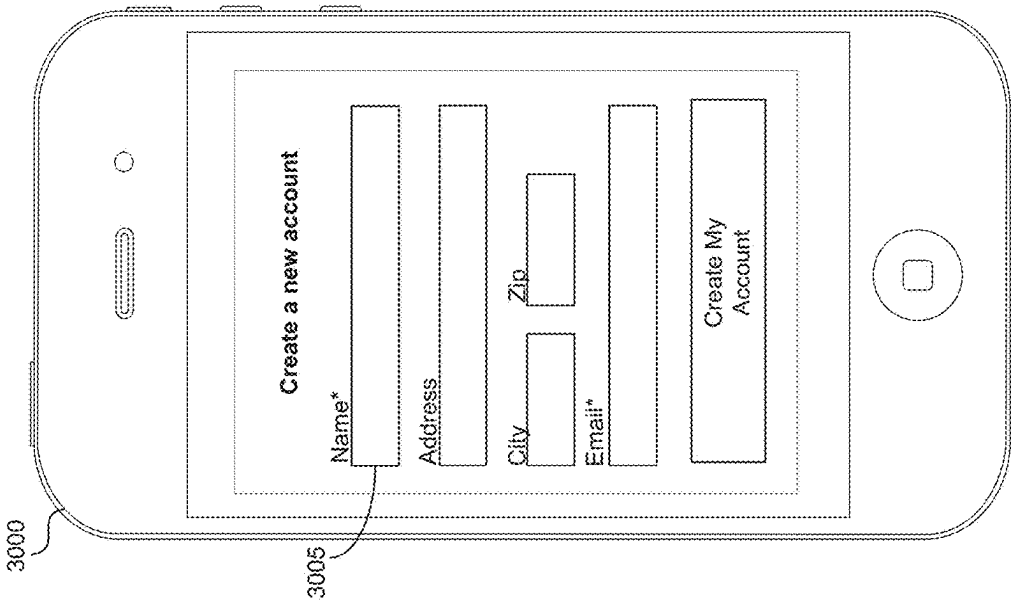

Create a new account
Name*
Address
City
Zip
Email*
Create My Account
3000
3005

FIG. 30

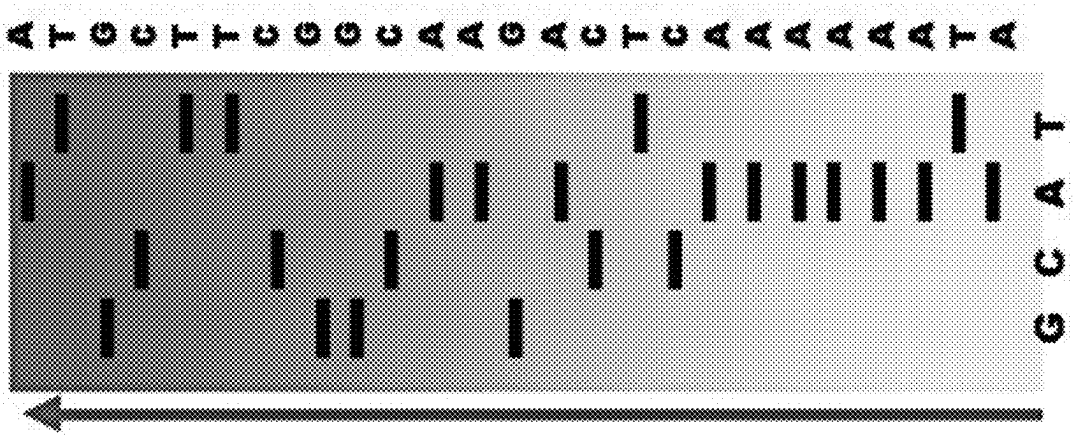


FIG. 31

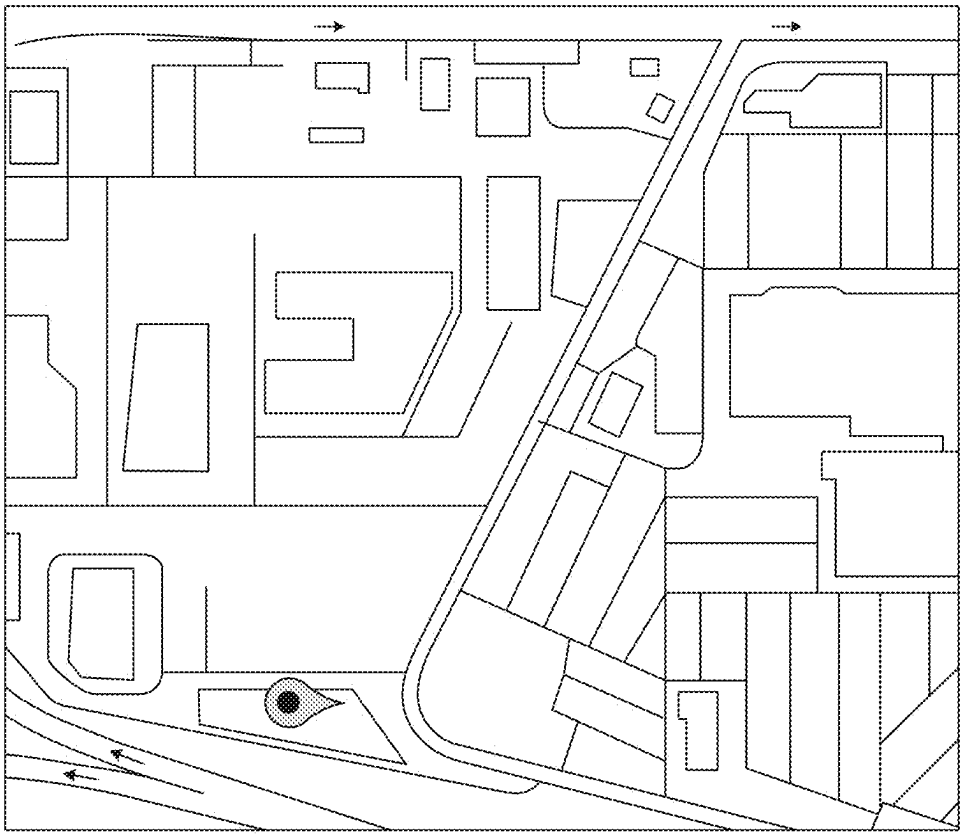


FIG. 32

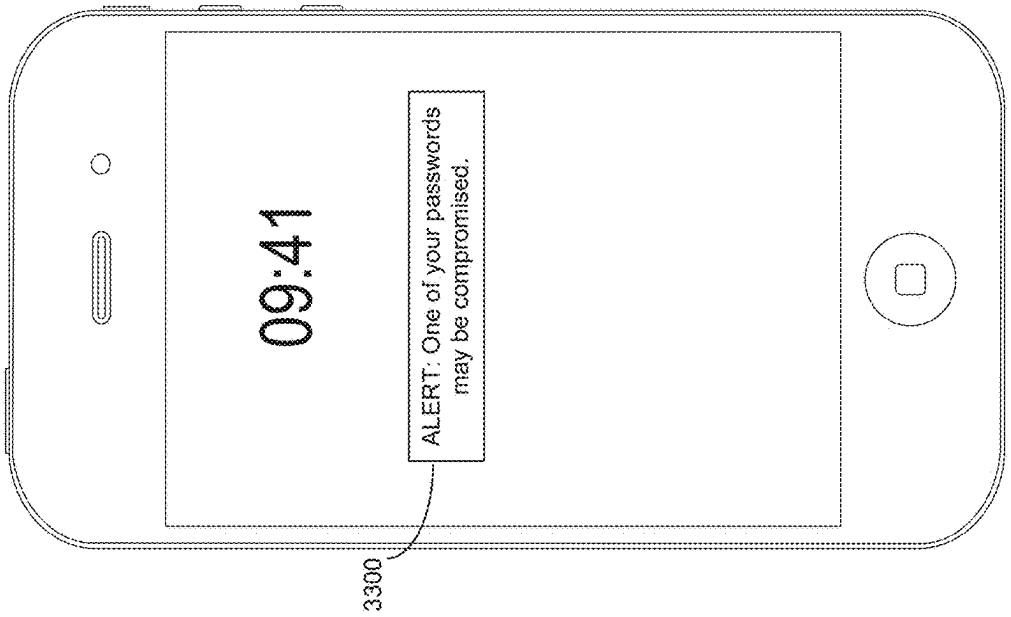


FIG. 33

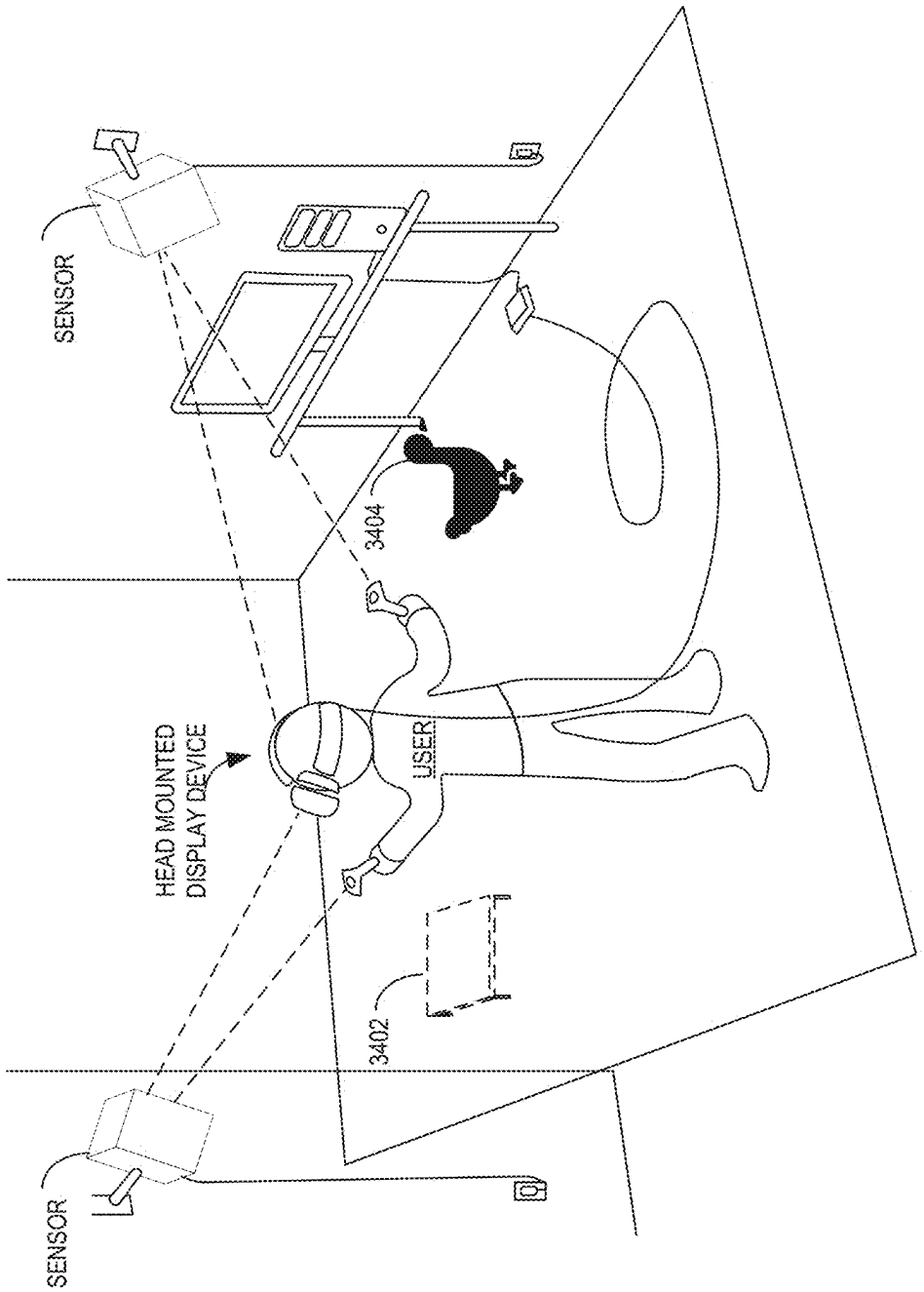


FIG. 34

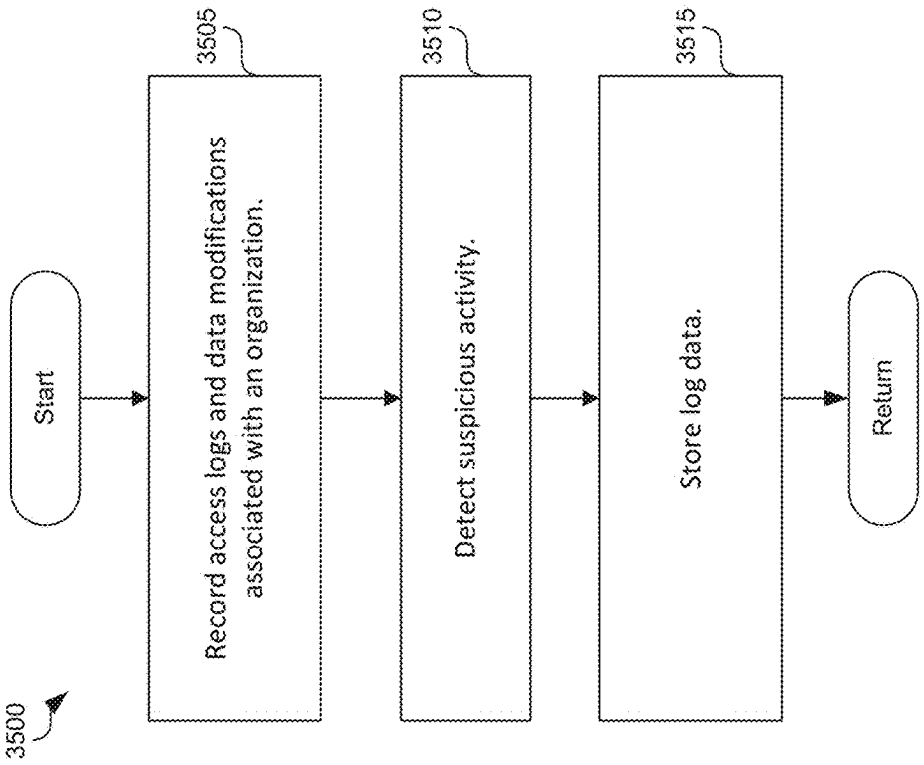

3500
Start
3505
Record access logs and data modifications associated with an organization.
3510
Detect suspicious activity.
3515
Store log data.
Return

FIG. 35

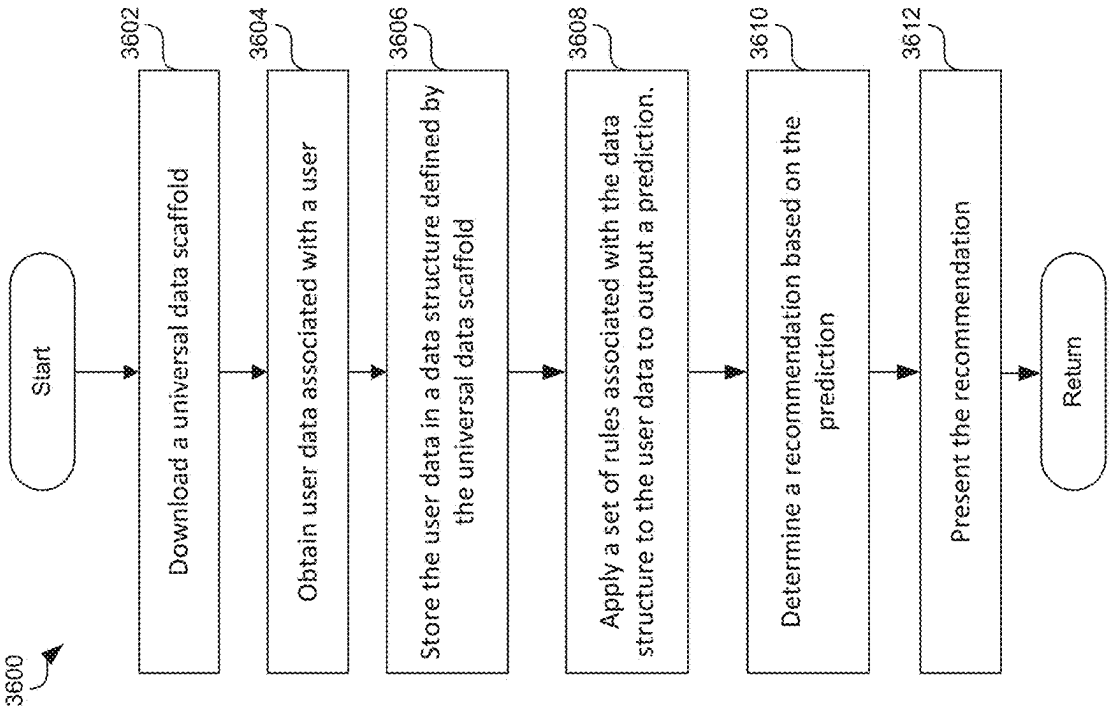

3600
Start
3602
Download a universal data scaffold
3604
Obtain user data associated with a user
3606
Store the user data in a data structure defined by the universal data scaffold
3608
Apply a set of rules associated with the data structure to the user data to output a prediction.
3610
Determine a recommendation based on the prediction
3612
Present the recommendation
Return

FIG. 36

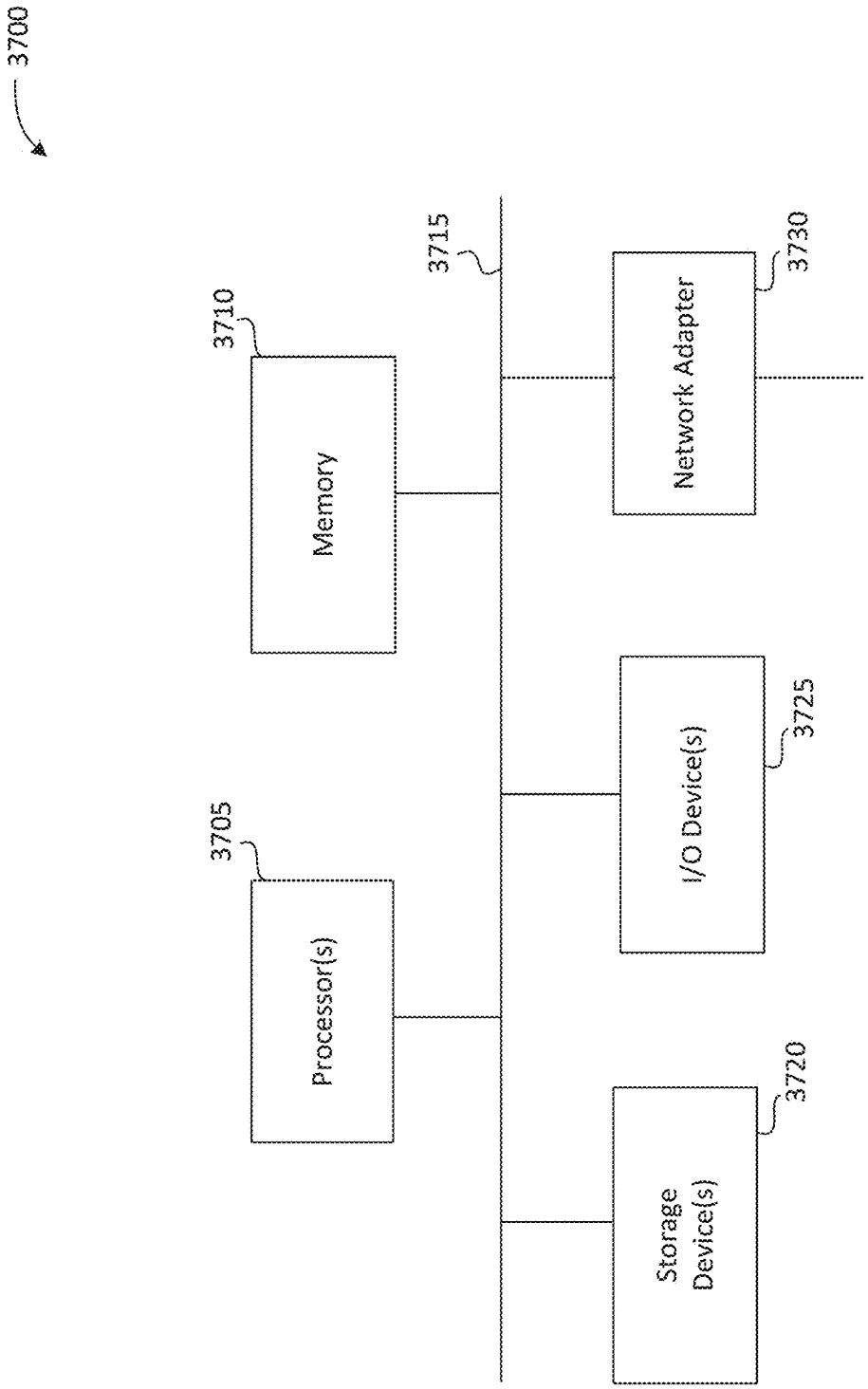

3700
3715
3710
Memory
3730
Network Adapter
3705
Processor(s)
3725
I/O Device(s)
3720
Storage Device(s)

FIG. 37

ZERO KNOWLEDGE PERSONAL ASSISTANT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 18/159,642, filed Jan. 25, 2023, which application claims the benefit of U.S. provisional patent application Ser. No. 62/302,892 filed Jan. 25, 2022, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] A file hosting service (e.g., Dropbox®, Google Drive®, or Microsoft OneDrive®) is an Internet-hosted service that is specifically designed to host user files. For example, a file hosting service may allow users to upload files that could then be accessed using a different computer, tablet, mobile phone, or other network-connected device. Users often have the option of sharing files publicly or keeping files protected (e.g., by requiring authentication prior to allowing access).

[0003] Some file hosting services also permit users to collaborate on digital files, such as word processor documents, spreadsheets, and Portable Document Format (PDF) documents. But file hosting services are subject to some constraints because they store digital files having unstructured data. For example, a file hosting service will only permit a user to view those digital files for which it has a viewer corresponding to the file type (e.g., PDF documents require a viewer such as Adobe Reader®). However, because many standard compliant formats are presented by viewers as visual renderings, the file hosting service is typically unaware of what the underlying data actually means.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a block diagram illustrating an environment in which the disclosed embodiments can be implemented.

[0005] FIG. **2** is a block diagram of a universal data scaffold template implemented by the data management platform of FIG. **1**, consistent with various embodiments.

[0006] FIG. **3** is a block diagram illustrating examples of universal data scaffold for multiple content types, consistent with various embodiments.

[0007] FIG. **4** is a block diagram illustrating an example of various content types supported by the data management platform, consistent with various embodiments.

[0008] FIG. **5** is a block diagram of examples of structuring digital content uploaded to the data management platform based on the universal data scaffolds, consistent with various embodiments.

[0009] FIG. **6** is a block diagram of an example of analyzing unstructured data associated with digital content to transform the unstructured data to a structured data of a specified content type, consistent with various embodiments.

[0010] FIG. **7**A is an example of a graph of the digital contents associated with a user, consistent with various embodiments.

[0011] FIG. **7**B is an example of a graphical representation of the digital contents in a graphical user interface, consistent with various embodiments.

[0012] FIG. **7**C is another example of a graphical representation of the digital contents in a GUI, consistent with various embodiments.

[0013] FIG. **7**D is another example of a graphical representation of the digital contents in a GUI, consistent with various embodiments.

[0014] FIG. **7**E is another example of a graphical representation of the digital contents in a GUI, consistent with various embodiments.

[0015] FIG. **8** is a block diagram of an example for generating recommendations based on intelligence derived from a graph of the digital contents, consistent with various embodiments.

[0016] FIG. **9** is a block diagram of zero-knowledge encryption of digital content, consistent with various embodiments.

[0017] FIG. **10** is a block diagram of an example of storing encrypted bundles in the data management platform and a server, consistent with various embodiments.

[0018] FIG. **11** is an example illustrating zero-knowledge data retrieval from the server, consistent with various embodiments.

[0019] FIG. **12** is a block diagram of an example for presenting offers to users of the data management platform, consistent with various embodiments.

[0020] FIG. **13** is a block diagram of the data management platform of FIG. **1**, consistent with various embodiments.

[0021] FIG. **14** is a block diagram of the server of FIG. **1**, consistent with various embodiments.

[0022] FIG. **15** is a flow diagram of a process for performing data management operations on the digital contents associated with a user, consistent with various embodiments.

[0023] FIG. **16** is a flow diagram of a process for displaying the digital contents on the user device, consistent with various embodiments.

[0024] FIG. **17** is a flow diagram of a process for performing zero-knowledge encryption of the digital contents in the data management platform, consistent with various embodiments.

[0025] FIG. **18** is a flow diagram of a process for decrypting the digital contents in the data management platform, consistent with various embodiments.

[0026] FIG. **19** is a flow diagram of a process for sending zero-knowledge offers to the users of the data management platform, consistent with various embodiments.

[0027] FIG. **20** is a flow diagram of a process for displaying the zero-knowledge offers to the users of the data management platform, consistent with various embodiments.

[0028] FIG. **21** shows a universal scaffolding data structure partially stored on a user device.

[0029] FIG. **22** shows a system to preserve a user's privacy by providing bundled answers.

[0030] FIG. **23** shows query resolution between user device and server using bundled data.

[0031] FIG. **24** is a flowchart of a method to provide an answer to a query generated by a user device by hiding the answer and the query from a server providing the answer.

[0032] FIG. **25** is a flowchart of a method to protect user data by obtaining an answer to a query from a server, without disclosing the query and/or the answer to the server.

[0033] FIG. **26** shows a manner of accessing a password in a recall-memory enhancing manner.

[0034] FIG. **27** shows a map specifying the geographic location to use in accessing a password modification functionality.

[0035] FIG. **28** shows a step in the process of authenticating a user or enabling password modification capability using a zero-knowledge database.

[0036] FIG. **29** shows an example implementation of a zero-knowledge personal assistant.

[0037] FIG. **30** shows a form including input fields that can be populated using a zero-knowledge database

[0038] FIG. **31** shows an example of DNA that can be defined using a universal data scaffold and stored in a data management platform.

[0039] FIG. **32** shows an example of location-sharing using a zero-knowledge database.

[0040] FIG. **33** shows an example of a notification.

[0041] FIG. **34** shows a user operating a virtual reality device that can display representations of content defined using a universal data scaffold.

[0042] FIG. **35** is a flow diagram illustrating a method of implementing a logging system using a universal data scaffold.

[0043] FIG. **35** is a flow diagram illustrating a method of implementing a zero-knowledge personal assistant.

[0044] FIG. **36** is a flow diagram illustrating a method of implementing a zero-knowledge personal assistant.

[0045] FIG. **37** is a block diagram of a computer system as may be used to implement features of some embodiments of the disclosed technology.

DETAILED DESCRIPTION

[0046] With a multitude of passwords in today's technologically enhanced world, where each password is a string of nonsensical alphanumeric characters, the user can easily forget a particular password. However, while users frequently forget a nonsensical password, users easily remember places, favorite songs, or other emotionally relevant items. The system disclosed here enables a user to access passwords in a recall-memory enhancing manner by tying password access to memorable items such as places, songs, images or other emotionally relevant items. The memorable items can be stored using a data management platform associated with a zero-knowledge database.

[0047] The data management platform provides a secure storage environment for digital content, such as digital files. The data management platform can represent the stored digital contents as a semantic graph. In the semantic graph, nodes represent digital contents and an edge between two nodes represents the relationship between the corresponding two digital contents. The semantic graph is constructed using structured data associated with the digital contents. The structured data allows the data management platform to collect, process, and present the digital contents in a graphical user interface in a more meaningful way. The data management platform also provides various other functionalities such as sharing of digital contents between users of the data management platform, presenting notifications regarding one or more aspects of a digital content, intelligent/context-based fetching or retrieval of relevant digital contents, zero-knowledge encryption of the digital contents, and generating zero-knowledge offers.

[0048] The data management platform facilitates storing of the digital content as structured data, which is defined using a universal data scaffold of the data management platform. A digital content is stored as one of multiple content types in the data management platform, and each content type is defined using a universal data scaffold. In some embodiments, a universal data scaffold includes a set of attributes that defines a content type. For example, for a content type such as a car, the universal data scaffold can include a set of attributes such as a make, a model, a year, a vehicle identification number ("VIN") of the car. When a user uploads a first digital content, such as picture of a car, or a bill of sale of the car, or creates a data record for a car, the data management platform determines the content type of the digital content as "car", obtains the universal data scaffold of "car," and obtains attribute values from the digital content, such as "Ford," "Fusion," and "2014," for the set of attributes defined in the "car" universal data scaffold. The data management platform can determine the type of the digital content based on appointing the workflow from which the document was uploaded. For example, if the document was uploaded in response to a question about a vehicle, the data management platform can determine that the type of digital content is a car.

[0049] The data management platform can have various such universal data scaffolds for multiple content types. One of the attributes in the universal data scaffold can also include a relationship attribute, which identifies a second digital content (of the same content type or another content type) related to the first digital content. For example, one of the attributes in "car" universal data scaffold can be a relationship attribute, such as "owner" or "owned by" which relates the car digital content to a "person" content type digital content. Structured data permits the relationship to be readily established between various digital contents. The universal data scaffolds can enable the data management platform to intelligently connect digital contents of different types having a common theme. For example, digital content such as documents related to a vehicle (e.g., maintenance records, driver licenses, and insurance policies) may be associated with one another and/or the individual who owns the vehicle. The connections formed between different structured data are what give the structured data its meaning.

[0050] The data management platform can also retrieve data from public databases such as the phone book, the Yellow Pages, a public criminal database, etc. Upon retrieving the data, the data management platform can format retrieved data into a universal data scaffold data structure. As a result, both the private data and the public data of the individual can be available to the data management platform to provide better recommendations or offers to the user.

[0051] The universal data scaffold can also be associated with other metadata, such as rules. A user can set various rules for the digital contents, such as a sharing rule that defines sharing of a digital content with another user. For example, in a universal data scaffold for a "child" content type, a parent user can set a sharing rule to share with a nanny user only a portion of digital contents related to the child, such as immunization records associated with the child.

[0052] The data management platform can be implemented in various configurations. For example, in a first configuration, the data management platform can be implemented at a server computing device ("server"), which a user can access from a user device using an application, such as a web browser on the user device. In the second configuration, a portion of the data management platform can also

be implemented at the user device, for example, as an "app" that can be downloaded to and executed at the user device. The user can access the app on the user device to upload and/or retrieve digital contents to and/or from the server. Regardless of which configuration the data management platform is implemented in, the server stores all universal data scaffolds. When a user downloads and installs the app, a copy of all the universal data scaffolds that are available at the server are also installed at the user device. When a universal data scaffold is updated at the server, e.g., attributes are added, removed, and/or modified, the updated universal data scaffold is transmitted to the data management platform on the user devices, e.g., as part of an app update.

[0053] The data management platform can store the digital contents as a graph database in which digital contents are represented as nodes of the graph. A relationship between two digital contents is represented by an edge connecting the nodes corresponding to the two digital contents. A node can be a data structure that contains the digital content, attribute values of the digital content, and an edge that connects the node to another node. Note that the digital contents can be stored in formats other than graph database. For example, the digital contents can be stored in a relational database. They can be stored in any format that allows the data management platform to obtain, derive determine, or interpret the structured data associated with and relationships between the digital contents based on the universal data scaffolds. The data management platform can present the digital contents in a graphical user interface (GUI) using which the user can view, modify, and/or create digital contents. The GUI makes use of the universal data scaffold associated with a digital content to show various attributes associated with the digital content and/or any related digital contents. For example, the GUI can show a picture of the car, and attributes such as Make, Model and Year of the car, which are derived from the universal data scaffold of the car. The GUI can also show related digital content, such as a license plate of the car, which is derived from the universal data scaffold of the car, e.g., from the license plate attribute in the universal data scaffold of the car.

[0054] The data management platform also supports zero-knowledge encryption of the digital contents, in which the data management platform encrypts the digital contents prior to storing them at the data storage system ensuring security and privacy of the digital contents. For example, the app can encrypt a node corresponding to the digital content and then transmit the encrypted node to the server to back up the digital content at the data storage system. When the node is encrypted, the data management platform generates an encrypted bundle, which is typically a blob, having an encrypted form of the digital content, including the attribute values of the digital content, and the universal data scaffold of the digital content. The encrypted bundle is then transmitted to the server for storage at the data storage system. The encryption is typically done at the user device, e.g., using an encryption key that only the user device has access to. Since the server would not have access to the encrypted key used the by the user device in encrypting the digital content, the encrypted bundle cannot be decrypted at the server, therefore making the digital content secure at the server. In some embodiments, the data management platform does not encrypt the digital contents in which case the digital contents are transmitted to and stored at the server without being encrypted. In some embodiments, the data management platform can provide an option to the user to disable the encryption in which case the digital contents are transmitted to and stored at the server without being encrypted. However, the digital contents stored at the server may be less secure in such scenarios compared to scenarios where they are stored as encrypted data.

[0055] The data management platform also facilitates zero-knowledge offers in which offers of goods and/or services are stored at user devices, e.g., as part of the universal data scaffolds, but are displayed to those users who satisfy a specified criterion, and the eligible user, if interested, may then accept, reject, or ignore the offer. Neither the data management platform nor a vendor who has provided the offer may know to which users a specified offer was displayed until a user accepts the specified offer. In some embodiments, even after the user accepts the specified offer, the data management platform may anonymize the acceptance, e.g. by removing some or all user identification information, before forwarding the acceptance to the vendor. In some embodiments, a zero-knowledge offer is an offer that may only be known to the user to whom the offer was displayed until acceptance. In fact, offers may simply be stored with the underlying universal data scaffolding of the digital content with which the offer is to be presented. For example, digital content having information pertaining to a nanny (or some other employee) may include an offer for a payroll service, an offer for a background check, etc. In some embodiments, the zero-knowledge offers are included as part of the universal data scaffolds, and would be stored on the user device when the user installs the data management platform on the user device. Because these offers can be programmed into the data management platform during development, the entity responsible for providing the good/service, such as a vendor, or the data management platform may not be aware that an offer was made to a user until a notification of acceptance is received from that user.

[0056] The universal data scaffolding enables all users to use the same storage architecture and rules to create various content types. Consequently, an entity responsible for supporting the storage of various content types need not worry about users generating digital contents of different content types that are incompatible with one another. Instead, the universal data scaffold can represent shared, common content types that share a commonality across the users of data management platform in how information is mapped. Thus, each user may populate a personalized database of digital contents using universal data scaffolding that appear similar to every user. This consistency can allow the content types to be universally shared, as well as support the private delivery of analytics/intelligence.

[0057] The server can provide an answer to a query generated by a user device without the answer and the query from a server providing the answer. The universal data scaffold can define data structures containing information such as information about restaurants, mechanics, medical conditions, etc. The server creates bundles including two or more data structures containing disparate information, and a unique identifier for each bundle. The server creates a table of contents indicating the unique identifier of a bundle and the information contained in the bundle and sends the table of contents to the user device. The server provides the answer to the query from the user device by receiving the unique identifier (ID) of the bundle and providing the bundle

having the unique ID to the user device. While the bundle contains the answer to the query, the server does not know the query or the answer because the bundle contains disparate information.

[0058] FIG. **1** is a block diagram illustrating an environment in which the disclosed embodiments can be implemented. The environment **100** includes a data management platform **110** that facilitates storage of digital content, such as digital files, at a server **120**. As described above, the data management platform **110** can be implemented in multiple configurations, and the environment **100** illustrates a configuration in which the data management platform **110** is implemented at a user device **105**. The data management platform **110** allows the user **135** to perform data management operations such as upload, download, generate, modify, and/or view digital content. In some embodiments, the data management platform **110** can be an app that can be downloaded to the user device **105** from an app store, which can be hosted at a server of a third-party entity **145**, and executed at the user device **105** to provide access to the server **120**. The server **120** can be accessible via the network **130**, such as Internet, local area network (LAN), or wide area network (WAN). The data management platform **110** provides a graphical user interface (GUI) **115** for the user **135** to perform the data management operations. In some embodiments, the data management platform **110** can be a web browser application on the user device **105**. The data management platform **110** can store the digital content at the user device **105**, e.g., on-device storage component. The data management platform **110** synchronizes with the server **120** to back up any new digital content uploaded or existing digital content modified by the user **135** to the server **120** for storage at a data storage system **125**.

[0059] The digital content can include any multimedia content such as an image file (e.g., Joint Photographic Experts Group (JPEG) files, Tagged Image File Format (TIFF) files, and Portable Document Format (PDF) files), an audio file (e.g., Waveform Audio (WAV) files and MP3 files), a video file (e.g., QuickTime File Format (QTFF) files, Audio Video Interleaved (AVI) files, and MP4 files), a document, a data record created in the server **120**, etc. The user device **105** can be any network-accessible computing device associated with a user **135**, such as a mobile phone, a tablet computer, a desktop computer, a laptop computer, a wearable electronic device (e.g., a watch or fitness band), a virtual/augmented reality device, a smart television, or some other internet of things (IoT) device.

[0060] The user **135** can upload a first digital content, such as an image of a car, to the data management platform **110** using the GUI **115**. The data management platform **110** determines whether the uploaded digital content is in a structured data format as defined by at least one of the multiple universal data scaffolds **155** of the server **120**, e.g., a first universal data scaffold. In some embodiments, the data management platform **110** has a copy of all the universal data scaffolds **155** at the user device **105**, e.g., which are bundled in the app that is downloaded to and installed at the user device **105**. However, if one or more of the universal data scaffolds **155** or other ad hoc data scaffolds that are at the server **120** but not available at the user device **105**, the data management platform **110** can retrieve them from the server **120**. If the first digital content is not in the structured data format defined by the first universal data scaffold, the data management platform **110** transforms the first digital content to the structured data format based on the first universal data scaffold, e.g., as described at least in association with FIG. **5** below, and stores the first digital content in the user device **105**. The user **135** can upload digital content to the data management platform **110** from the user device **105** and/or from one or more digital content sources **140**, such as an external storage device connected to the user device **105**, or online data storage services. The data management platform **110** enables the user **135** to view the digital contents in the GUI **115** example of which is described at least with reference to FIG. **7**B below. The user **135** can navigate through the GUI **115** to view, edit and/or create digital content.

[0061] The data management platform **110** synchronizes the user device **105** with the server **120** to back up the digital content stored at the user device **105** to the server **120**, e.g., based on a trigger condition. A trigger condition that initiates the backup of the digital content to the server **120** can include one or more of a scheduled time interval, a receipt of a command from the user **135**, opening of the data management platform **110** on the user device **105**, closing of the data management platform **110** on the user device **105**, number of digital content that has not been backed up exceeds a specified threshold, a memory of the user device **105** consumed by the data management platform **110** exceeds a specified threshold, etc. The server **120** can store the backed up digital content at the data storage system **125**.

[0062] The data management platform **110** can encrypt the digital content prior to backing them up to the server **120**. For example, the data management platform **110** can encrypt a node corresponding to the first digital content and then transmit the encrypted node to the server **120** to back up the first digital content at the data storage system **125**. When the node is encrypted, the data management platform **110** generates an encrypted bundle having an encrypted version of (a) the first digital content, including attribute values of the first digital content, and (b) the first universal data scaffold of the first digital content. However, in some embodiments, the universal data scaffolds in the encrypted bundles may not be encrypted as they are not private to a specific user and common across the users of the data management platform **110**. The encrypted bundle is then transmitted to the server **120** for storage at the data storage system **125**.

[0063] The server **120** co-ordinates or facilitates various data management operations performed by the user **135**. For example, the server **120** responds to storage requests from the user **135** by storing the encrypted digital content received from the user device **105** at the data storage system **125**. The server **120** can also respond to data access requests from the user **135** by retrieving the digital content from the data storage system **125** and forwarding them to the user device **105**. The server **120** manages digital contents of multiple users in which each user has a separate user account or user profile at the server **120**. The server **120** may store digital contents of multiple users in the data storage system **125**.

[0064] The server **120** also facilitates zero-knowledge offers in which offers of goods and/or services are stored at user devices but are displayed to those users who satisfy a specified criterion, and the eligible user, if interested, may then accept, reject, or ignore the offer. Neither the server **120** nor a vendor, e.g., one of the third-party entities **145**, who provided the offer to the server **120** to be distributed to the

users may know to which users a specified offer was displayed until a user accepts the specified offer.

[0065] The data management platform **110** is also compatible with data storage archives that are designed based on customized data scaffolds. A customized data scaffold archive **150** manages digital content that are structured based on customized data scaffolds, that is, a data scaffold that is different from the universal data scaffold defined in the data management platform **110**. For example, a car dealer may want to have a different data scaffold for a car than the universal data scaffold defined for a car by the data management platform. That is, the customized data scaffold can have a first set of attributes defining a car, whereas the universal data scaffold may have a second set of attributes. The data management platform **110** includes an application programming interfaces (APIs) that enable importing and/or exporting digital content from/to the customized data scaffold archive **150** while still maintaining the structured data associated with the digital content. The APIs can determine differences between the two data scaffolds (e.g., universal data scaffold for a car and the customized data scaffold for the car), obtain attribute values for any attributes that need to have a value but don't, and store the digital content with the corresponding structured data accordingly. In some embodiments, the customized data scaffold archive **150** can be created by the same entity as the data management platform **110** and then offered to another entity, e.g., a buyer such as an organization, for sale.

[0066] FIG. **2** is a block diagram of a universal data scaffold template **200** implemented by the data management platform of FIG. **1**, consistent with various embodiments. Structured data allows the data management platform **110** to collect, process, and present information in a more meaningful way. For example, if the user **135** uploads a digital content indicating that they own a vehicle, the data management platform **110** may begin analyzing other digital content to identify a driver license of a primary driver, a license plate, insurance documentation, etc., related to the vehicle. Such an analysis and/or intelligence of the data management platform **110** is made possible using a universal data scaffold, which defines a structured data format for digital belongings to be stored by the data management platform.

[0067] A universal data scaffold is defined based on universal data scaffold template **200**, which includes universal definition **205** and metadata **250**. The universal definition **205** provides a template of variables for defining a set of attributes of a content type. For example, the universal definition **205** includes a type variable **210** that is used to define a content type; a field variable **215** to define one or more attributes of the content type; a field data type variable **220** to define a data type of the attributes; a formatter variable **225** to define a format in which the content type is to be displayed; a translation variable **230** to define translation for one or more attributes; and a relationship variable **235** to define relationship with other digital contents.

[0068] The metadata **250** provides various settings and/or rules using which the user can customize the behavior of digital content in the data management platform **110**. The sharing rule **251** can be used by the user to set rules for sharing a digital content with other entities, e.g., another user or another user device of the same user. For example, a first user, such as a parent of a child, can define a sharing rule **251** to share a subset of digital contents associated with the child, e.g., immunization records, with another user, such as a nanny.

[0069] The security rule **252** can be used to set rules regarding access permissions for a digital content for various entities. For example, the parent can define a security rule **252** to provide the nanny read-only access to the immunization records.

[0070] The notification rules **253** can be used to set rules regarding generating notifications. For example, the parent can define a notification rule **253** to generate a notification on a user device associated with the parent, when the child is up for a particular vaccination, which can be determined based on the immunization records stored in the server **120**. The notification rule **253** also enables the user to set a frequency of the notification, a timing of the notification of an event prior to the occurrence of the event, etc.

[0071] The location-based rule **254** allows the user to define any location-specific rules. For example, the parent can define a location-based specific rule **254** to display a specified digital content, e.g., the immunization record or a doctor's note from a previous visit, when the parent is at or near a pediatrician's clinic, which can be determined based on location-based services in the user device carried by the parent.

[0072] The device-specific rule **255** can be used to set rules specific to a particular user device. For example, the parent user can set a device-specific rule **255** rule for showing a specified digital content by default when the data management platform **110** is opened at the user devices, such as to show a first digital content in a first user device and a second digital content in a second user device.

[0073] The relationship-specific rules **256** can be used by the user to set rules based on a specified relationship between the digital contents, or between users of the data management platform **110**. For example, a first user, e.g., father of a child, can set a relationship-specific rule **256** to share all digital content associated with the child of the first user with a second user, e.g., a mother of the child.

[0074] Note that the universal data scaffold template **200** is not limited to the above universal definition **205** and the metadata **250**. The universal definition **205** can have more or less definitions, and the metadata can have more or less rules, and other settings associated with the digital content. For example, metadata **250** can include tags and/or references that describe the universal definition **205** with which the metadata is associated. The universal definition **205** can also include links to other related universal definitions **205**, such as links shown in FIG. **7**A between person **705** and driver's license **726**, car **710**, etc.

[0075] FIG. **3** is a block diagram illustrating examples of universal data scaffold for multiple content types, consistent with various embodiments. The data management platform **110** supports storing digital content of various content types and each content type is defined using a universal data scaffold. A car universal data scaffold **305**, which is defined using the universal data scaffold template **200**, includes a set attributes that defines a digital content of the type "car." For example, the set of attributes that defines the content type "car" include "make," which is of data type string, "model," which is of data type string, "year," which is of data type date, and "VIN" which is of data type string. When a user stores a digital content of content type of "car" in the data management platform **110**, the data management platform

110 obtains attribute values for the above attributes defined in the car universal data scaffold 305, e.g., either by prompting the user to manually provide the above attribute values or by automatically analyzing the digital content, which is described at least with reference to FIG. 5. For example, when the user 135 uploads a first digital content, such as picture of a car, or a bill of sale of the car, the data management platform 110 can analyze the digital content to identify the content type as "car", and obtain attribute values from the first digital content for the attributes make, model, and year as "Ford," "Fusion," and "2014," respectively.

[0076] The car universal data scaffold 305 further includes relationship attributes such as "driven_by," "owner" and "photo" which define a relationship with other digital content, such as a person who drives the car, a person who owns the car, and a photo of the car, respectively. That is, the relationship attribute can identify a digital content related to the first digital content. Further, the related digital content can be of the same content type as the first digital content or of different content type. For example, the first digital content, such as a Ford Fusion car of the above example, can have a second digital content of type "person," which can be a data record of the user "John," as an attribute value of the relationship attributes "driven_by" and the "owner," and a third digital content of type "photo" can be an attribute value of the attribute "photo." In some embodiments, it is because of such relationships between different digital contents or content types, the data management platform 110 can mine the data storage system 125 for determining related digital content and link/or connect the related digital content. In some embodiments, the data management platform 110 will also prompt the user 135 when the user 135 uploads a digital content of the first content type to identify a related digital content, which can be of the same or different content type, in which such a determination is made based on the relationship attributes defined in the universal data scaffold for the first content type.

[0077] Note that some attributes of the car universal data scaffold 305, such as make, model, year and VIN, are native to the content type to which the universal data scaffold corresponds, e.g., direct values of the digital content, while other attributes, such as "driven_by," "owner," and "photo" are of derived type, e.g., values are derived from other content type. Further, note that not all attributes of a universal data scaffold may have attribute values. For example, the user 135 may not input, or the data management platform 110 may not determine, a value of a particular attribute, e.g., VIN, of the car universal data scaffold 305. In some embodiments, the universal data scaffold may define at least some attributes as mandatory, which requires the user to input the value if the data management platform 110 is not able to determine one.

[0078] The car universal data scaffold 305 is defined based on the universal data scaffold template 200. For example, the type "car" corresponds to the type variable 210, the attributes make, model, year and VIN corresponds to the field 215 variable and the data types of the attributes correspond to the field data type variable 220, and the relationship attributes "driven_by," "owner," and "photo" correspond to the relationship variable 235. The universal data scaffold template 200 also allows the user 135 to define ad hoc relationships between digital contents. Note that a universal data scaffold may not define all variables of the universal data scaffold template 200. The car universal data scaffold 305 can also include metadata (not illustrated), such as the metadata 250, which includes various settings and/or rules that the user can set or customize. In some embodiments, the rules in the metadata can have default values, which the user 135 can choose to customize.

[0079] FIG. 3 also illustrates a person universal data scaffold 310, which is used to define a content type "person." That is, the person universal data scaffold 310 defines structured data associated with a person, and can include attributes such as a first name, middle name, last name, date of birth, address, email, and phone. The user 135 can use the person universal data scaffold 310 to store information associated with a person. A digital content of type "person" can be created in various ways, e.g., by uploading a picture of a person, identification document of a person, or just by creating a data record of the person in the GUI 115. For example, a digital content of type "person" for a user, John, can have attribute values such as "John," "M.," "Grisham," "Dec. 31, 1899" for the attributes a first name, middle name, last name, and date of birth, respectively, defined in the person universal data scaffold 310. In the example of car universal data scaffold 305, John can be represented as the driver and owner of the ford fusion car by linking the first digital content, which represents the Ford Fusion car, with the second digital content, such as a data record of John, by inputting the attribute values of the relationship attributes "driven_by" and the "owner," as "person.p1," wherein "person" is content type of the second digital content and "p1" is an object identifier of the second digital content. Note that the above syntax is just for illustration and various other forms of representation may be used for specifying a digital content as an attribute value.

[0080] The universal data scaffolding enables the data management platform 110 to make intelligent determinations because the universal data scaffolding is common across the users of the data management platform 110. For example, the data management platform 110 may be able to determine when the driver license, license plate, lease term, or insurance coverage will expire, and then take appropriate action, such as generating a notification at the user device 105 reminding the user 135 to renew the driver's license.

[0081] The data management platform 110 defines various such universal data scaffolds for different content types. FIG. 4 is a block diagram illustrating an example 400 of various content types supported by the data management platform 110, consistent with various embodiments. The user 135 can upload digital content of many content types, e.g., content types 410, to the data management platform 110. In the example 400, the content types 410 supported by the data management platform 110 include a car, a dog, a recipe, a house, a receipt, and a photo. Each of the content types 410 is defined using a separate universal data scaffold. For example, the content type "car" is defined using the car universal data scaffold 305 of FIG. 3. Similarly, the content type "dog" can be defined using a dog universal scaffold, which can include attributes such as a breed, name, date of birth, photo, medicine, tag, Vet, walker, and genetic test. By building a storage archive of digital content of various content types 410, and structuring the digital content using the universal data scaffolds, the data management platform 110 can make intelligent determinations about various aspects of the digital content, such as keeping track of various dates and generating notification reminders and/or making recommendations to the user 135. For example, if

the user **135** has stored digital content of type "dog," such as pictures and/or information about a dog of the user **135**, the data management platform **110** can make a recommendation to the user **135** to get a genetic test done for the dog in an event the data management platform **110** determines that there are no attribute values associated with the attribute "genetic test" of the dog universal data scaffold.

[0082] FIG. **5** is a block diagram of examples of structuring digital content uploaded to the data management platform **110** based on the universal data scaffolds, consistent with various embodiments. In the examples **510**-**520**, the data management platform **110** receives the digital content, analyzes the digital content to determine if any transformation to structured data is necessary, transforms, if necessary, the unstructured data to structured data based on a universal data scaffold associated with the content type of the digital content, and then stores the digital content in association with the universal data scaffold.

[0083] In the first example **510**, the data management platform **110** identifies a content type of the digital content based on one or more input fields using which the user **135** inputs data associated with the digital content, and then stores the digital content in association with a universal data scaffold of the identified content type. The GUI **115** can provide different sets of input fields for receiving data of different content types. That is, certain input fields may be directly associated with certain universal data scaffold. Accordingly, by the virtue of the user **135** entering information in those fields, the data management platform **110** may inherently understand the content type and the structure of the data being entered. For example, the GUI **115** can include a first set of input fields configured to receive data for content type "car." The data management platform **110** determines that any data input using the first set of input fields is structured data associated with the content type "car," and therefore, stores that structure data in association with the car universal data scaffold.

[0084] In the second example **515**, the data management platform **110** determines the content type of the uploaded digital content automatically, prompting the user **135** to identify the content type, or a combination. FIG. **6** is a block diagram of an example **600** of analyzing unstructured data associated with digital content to transform the unstructured data to a structured data of content type "receipt," consistent with various embodiments. The user **135** can upload an image file **605**, which is a scan of a restaurant bill. The data management platform **110** can analyze the image file **605** using various techniques, e.g., optical character recognition (OCR), and identify the word "Receipt," "bill" or the like in the image file **605**, and determine the image file **605** to be of content type "receipt." The data management platform **110** can also determine the content type based on at least one of user input, machine learning techniques, or deductive inference rules. After determining the content type, the data management platform **110** can then retrieve the receipt universal data scaffold, which is a universal data scaffold defined for content type "receipt," and determine a set of attributes **610** of the receipt from the receipt universal data scaffold, such as a restaurant name, date, price, and expense type. The data management platform **110** can continue to analyze the image file **605** to obtain or extract attribute values for the set of attributes **610**. For example, the data management platform **110** can obtain the values for the attributes restaurant name, date, and price as "Murphy's Deli," "Jun. 2, 2017" and "$1264," respectively. However, the data management platform **110** may not obtain the value for the attribute expense type. The data management platform **110** may prompt the user **135** to identify the expense type and receive the value from the user **135**. Thus, the data management platform **110** has transformed the unstructured data associated with the image file **605** to structured data of a content type "receipt" based on the receipt universal data scaffold.

[0085] In the example **600**, the data management platform **110** determined some attribute values automatically and some by seeking input from the user **135**. In some embodiments, the data management platform **110** may automatically determine the necessary information in determining the structured data and not seek any input from the user **135**. For example, if the expense type is not a mandatory field, the data management platform **110** can end the analysis process after determining the attribute values for the other attributes (e.g., restaurant name, date, and price) and store the structured data. In some embodiments, the data management platform **110** can be even more interactive with the user **135** in determining the necessary information for generating the structured data. For example, if the data management platform **110** is not able to automatically determine the content type, the data management platform **110** may present a question such as "What is this content? Please choose content type" and present a list of content types for the user **135** to choose from. In some embodiments, the data management platform **110** may have automatically determined the content type as "receipt" but the accuracy of the determination may be below a predefined threshold, and therefore, the data management platform **110** can present a question such as "Is this a receipt? Please confirm or choose another content type." The data management platform **110** can continue to ask the user **135** to confirm after each attribute value is determined or all at once.

[0086] Continuing with FIG. **6**, in yet another example, the data management platform **110** can be configured, e.g., using one of the rules in metadata associated with receipt universal data scaffold, to request if the user **135** wants to add a mileage receipt if the expense type of the restaurant bill is "business." The degree of automation, or in other words, interaction between the user **135** and the data management platform **110**, in transforming the unstructured data to structured data can be configured by the user **135**, e.g., in one of the setting options provided by the data management platform **110**. For example, the degree of automation can be configured in three different levels as "low," "medium," and "high" in which low indicates a lowest of three levels of automation—the number of questions presented to the user may be above a first threshold, "high" indicates a highest level of automation—the number of questions presented to the user **135** may be below a second threshold (second threshold being lower that first threshold), and "medium" indicates a level of automation between "low" and "high"—the number of questions presented to the user **135** may be between the first and second thresholds.

[0087] Referring back to FIG. **5**, in the third example **520**, the user **135** inputs the digital content of a specified content type in a structured format, and the data management platform **110** intelligently identifies the content type and stores the digital content in association with the universal data scaffold defined for the corresponding content type. For example, the user **135** can specify that the user is uploading

an image file of a W2 document, or the data management platform **110** analyzes the W2 document, e.g., using OCR, to determine the image file is of type "W2," and the data management maps the image file to the W2 universal data scaffold. The data management platform **110** continues to analyze the W2 document, e.g., using OCR, to obtain the attribute values of the attributes defined in the W2 universal data scaffold, and stores the structured data, e.g., the image file and attribute values, in association with the W2 universal data scaffold. In some embodiments, the user **135** can receive a digital content in structured data format from another user of the data management platform **110** and upload the received digital content to the data management platform **110**. In such embodiments, the data management platform **110** can readily identify the structured data based on the universal data scaffold associated with the received digital content, and store it accordingly.

[0088] Structured data allows the data management platform **110** to collect, process, and present information in a more meaningful way. For example, if the user **135** uploads a digital content, such as an image of a car or a data record of the car, indicating that they own a vehicle, the data management platform **110** may begin analyzing other digital content to identify a driver license of a primary driver, a license plate, insurance documentation, etc., related to the vehicle. The data management platform may automatically link those digital contents as related to the car, prompt the user **135** to confirm that the documents are indeed related, or even prompt the user **135** to identify the related documents. Such an analysis and/or intelligence of the data management platform **110** is made possible by the use of a universal data scaffold.

[0089] FIG. **7**A is an example of a graph **700** of the digital contents associated with a user, consistent with various embodiments. As described above, the digital contents are stored in the data storage system **125** as a graph database, for example as graph **700**. The graph **700** represents digital contents as nodes, and relationships between the digital contents as edges connecting the nodes. For example, the graph **700** represents a first digital content, such as a data record or photo of a person, as a first node **705**, a second digital content, such as a data record or photo of a car, as a second node **710**, and a third digital content, such as an oil change receipt, as a third node **725**. Further, an edge **720** connecting the first node **705** and the second node **710** indicates a relationship **715** of "primary driver" between the digital content corresponding to the nodes in which the person corresponding to the first node **705** is a primary driver of the car corresponding to the second node **710**.

[0090] FIG. **7**B is an example of a graphical representation **750** of the digital contents in a GUI, consistent with various embodiments. In some embodiments, the graphical representation **750** can be generated in the GUI **115**. The graphical representation **750** includes a digital content such as a picture **755** of a car, and multiple attributes **760** of the car, such as mileage, purchase date and VIN of the car. The picture **755**, and attributes **760** and their values can be obtained from the graph **700**, e.g., second node **710**. The graphical representation **750** also displays a license plate picture **765** of the car, which can be obtained from the second node **710** if the license plate is defined as an attribute of the car, or from another node (not illustrated) of the graph **700** if the license plate is defined as a related digital content.

[0091] The graphical representation **750** also includes a tool bar **770** that provides several GUI elements using which the user **135** can perform several data management operations, such as add or remove a picture, change attribute values associated with the digital content displayed in the graphical representation **750**, or identify related digital content. In some embodiments, at least some of the operations allowed by the tool bar **770** are context sensitive to the type of digital content displayed in the graphical representation **750**, which is determined based on the universal data scaffold the digital content is associated with. For example, if the content type is a car such as the car **755** in the graphical representation **750**, then based on the car universal data scaffold **305**, the tool bar **770** can allow the user **135** to perform operations pertinent to the content type "car" such as viewing additional pictures of the car **755**; viewing/editing a primary driver or owner associated with the car **755**; viewing/editing attribute values associated with the car **755**; viewing/editing maintenance records associated with the car **755**; viewing/editing important dates associated with the car **755**, such as an expiration date of the registration of the car; etc. In another example, if the content type of the digital content displayed in the graphical representation **750** is a "person", then based on the person universal data scaffold **310**, the tool bar **770** can allow the user **135** to perform operations including viewing additional pictures of the person; viewing/editing attributes associated with the person such as a first name, middle name, last name, a photo of the person; viewing/editing contact details; viewing/editing family or friends information associated with the person; viewing/editing important dates associated with the person, such as birthday, wedding anniversary, etc. Note that the graphical representation **750** can include GUI elements other than the tool bar **770**, which can provide the same operations as the tool bar **770** or different operations.

[0092] FIG. **7**C is another example of a graphical representation **775** of the digital contents in a GUI, consistent with various embodiments. The graphical representation **775** includes a digital content such as a picture **776** of a car, and multiple attributes **777** of the car, all of which can be obtained from a graph of the digital contents, such as second node **710** of the graph **700**. The graphical representation **775** also displays a license plate picture **779** of the car, which can be obtained from the second node **710**. The graphical representation **775** also displays information regarding a primary driver of the car **776**, which can be obtained from the first node **705** based on the relationship **715**. The graphical representation **775** also displays information regarding a primary driver **778** of the car **776**, which can be obtained from the first node **705** based on the relationship **715**, and a picture of the driver's license of the primary driver **778**, which can be obtained from the third node **726** based on the relationship **727**.

[0093] FIG. **7**D is another example of a graphical representation **780** of the digital contents in a GUI, consistent with various embodiments. The graphical representation **780** includes the picture **776** of the car, the license plate picture **779** of the car and a first section **781** that displays information regarding insurance policy of the car **776**, which can be obtained from a specified node (not illustrated) related to the second node **710** based on the relationship such as "insurance policy." The graphical representation **780** also displays the insurance policy documents **782**, which can be obtained from the specified node. In some embodiments, the user **135**

may navigate to the graphical representation **780** by scrolling the graphical representation **775**.

[0094] FIG. **7**E is another example of a graphical representation **785** of the digital contents in a GUI, consistent with various embodiments. The graphical representation **785** includes the picture **776** of the car and a second section **786** that displays information regarding the insurance policy of the car **776**, such as insurance agent and carrier, which can be obtained from a specified node (not illustrated) related to the second node **710** based on the relationship such as "insurer." In some embodiments, the user **135** may navigate to the graphical representation **785** by selecting one of the GUI elements in the graphical representation **780**.

[0095] In some embodiments, the data management platform **110** downloads or caches a subset of the digital content associated with the user **135** at the user device **105**. The user **135** may navigate through the graphical representation **750** to view different digital contents and if a digital content is not stored in the user device **105**, then the data management platform **110** obtains the digital content from the server **120**. For example, in the graphical representation **750** if the user **135** selects an option from the tool bar **770** to view information regarding the owner or the primary driver of the car, and if the corresponding data, e.g., the first node **705**, is not stored at the user device **105**, the data management platform **110** can fetch the first node **705** from the server **120**, and then retrieve the details of the owner, such as a picture and name of the owner, from the first node **705**, and display the details of the owner in the graphical representation **750**.

[0096] In some embodiments, the data management platform **110** can display some of the digital contents in the graphical representation **750** by default, e.g., when the data management platform **110** is opened by the user **135**. The data management platform **110** can select the digital contents to be displayed by default regardless of whether the user **135** requested for them. The selected digital contents are fetched from the server **120** and cached at the user device **105**. The selection can be done based on context associated with the user **135**, such as, the geographical location the user **135** is at, the date/day/time of the year/month/week, another user the user **135** is with, most frequently viewed digital content, most recently viewed digital content, digital content indicated as favorite, based on chronological order of the digital content added, based on a prediction that the user **135** may access a specified digital content (which can be determined based on a data access pattern of the user **135**), any other real-time characteristic associated with the user **135**, such as relevance of a current occasion, date, time, day, year, geographical location, etc. For example, if the user **135** is at a particular place, such as "Golden Gate" bridge in San Francisco, California, USA, the graphical representation **750** may display pictures that were captured at or near the Golden Gate bridge. In another example, if the user **135** is at a pediatrician clinic, and if the data management platform **110** determines that the user **135** has stored digital content associated with a child, such as immunization records of the child, results of lab tests, or medical reports, the graphical representation **750** may display the corresponding digital content. In still another example, the data management platform **110** may determine on a specific day that a year ago on the same date, the user **135** was vacationing in Hawaii, and the graphical representation **750** may display pictures associated with the vacation in Hawaii. In still another example, the data management platform **110** may determine that a specific day is a birthday of the user **135**, and the graphical representation **750** may display on the birthday of the user **135** pictures associated with prior birthday celebrations of the user **135**. In yet another example, if the data management platform **110** determines that the user **135** is with another user of the data management platform **110**, a second user, the graphical representation **750** may display digital content associated with both the users, e.g., pictures of occasions that are associated with both the users such as a get-together of both the users. In some embodiments, the user **135** may also customize the display settings in the data management platform **110** that indicates user-defined criteria for selecting digital content to be displayed in the graphical representation **750** by default.

[0097] The structured data associated with the digital content, which is generated based on universal data scaffolds of the corresponding content type, enables the data management platform **110** to identify the related digital content, relationships between the digital content and generate the graphical representation **750**. By representing the digital content as a semantic graph, such as in the graph **700**, the data management platform **110** gives more meaning and/or context to the digital content hosted by the data management platform **110**. The user **135** can make more meaningful use of the digital content. For example, while the second node **710**, which corresponds to a car has structured information such as a first name, middle name, last name, a photo of the person, the relationships the second node **710** has with other nodes is what gives the structured data its context or meaning, such as (a) the car is driven by the person corresponding to the first node **705** and (b) oil change was performed on the car as indicated by the third node **725**. In another example, the user **135** can quickly and easily navigate to the node corresponding to the driver's license, and open the driver's license to review, e.g., check the expiration date on the driver's license.

[0098] In some embodiments, the user **135** can share a digital content with another user of the data management platform **110**. For example, a specified user can request the data management platform **110** at the specified user's user device to obtain a group of digital contents associated with the user **135**. When the data management platform **110** on the user device **105** receives the request, the data management platform **110** at the user device **105** determines based on the metadata, e.g., sharing rules, associated with the universal data scaffolds of the group of digital contents, whether the group of digital contents can be shared with the specified user. In an event the data management platform **110** at the user device **105** determines that the group of the digital contents can be shared with the specified user, the data management platform **110** sends a message having the group of the digital contents to the specified user's user device. In some embodiments, the message can be sent to the specified user's user device via the server **120**. The data management platform **110** at the specified user's user device receives the message, and performs the necessary operations to merge the received group of digital contents with the digital contents associated with the specified user, e.g., based on the universal data scaffolds associated with the digital contents being merged, and displays the group of digital contents to the specified user, e.g., in the graphical representation **750**.

[0099] FIG. **8** is a block diagram of an example for generating recommendations based on intelligence derived

from a graph **800** of the digital contents, consistent with various embodiments. In some embodiments, the graph **800** is similar to the graph **700** of FIG. **7**A, and the graph **800** may contains a subset of the entire digital content associated with the user **135**. The data management platform **110** can make use of the structured data associated with the digital content and the relationships between the nodes in the graph **800** to derive various types of intelligence, and generate recommendations, offers and/or notifications based on the derived intelligence. For example, the data management platform **110** can analyze the graph **800** to make a recommendation for a scenario such as "Is there a car that has not had maintenance in 3 months?" and if so, generate a recommendation to recommend the user **135** to get the maintenance work done on the car. The data management platform **110** can also generate a notification that reminds or alerts the user **135** that a maintenance is due soon or past due. Furthermore, the data management platform **110** can also present an offer for maintenance work from a particular vendor (e.g., one of the third-party entities **145**) to the user **135**.

[0100] In some embodiments, to derive intelligence for such scenarios, the data management platform **110** can navigate the graph **800** in various paths (e.g., series of edges) and test for the presence/absence of nodes, and filter on attributes of the nodes and edges. For example, to derive the intelligence for the above scenario, the data management platform **110** navigates a first path **810** from first node **705** to third node **725** to determine if the person is associated with a car, and since the person is associated with the car as indicated by the second node **710** the data management platform **110** proceeds to determine if the car is associated with a maintenance record, and since the car is associated with a maintenance record as indicated by the third node **725**, the data management platform **110** proceeds to determine from the attributes of the third node **725** a date of the recent most maintenance. If the date of the maintenance is outside of 3 months, the data management platform **110** can proceed with generating a recommendation for the user **135**, which can be displayed to the user **135** in the GUI **115**.

[0101] In another example, the data management platform **110** can similarly navigate a second path **805** from first node **705** to the fourth node **815** to determine if the person's driver license is due to expire in a specified period, e.g., 3 months, and if so, generate an appropriate recommendation.

[0102] In some embodiments, each such scenario can be expressed as a query, and the result of the query is what triggers the data management platform **110** to make a recommendation or extend an offer.

[0103] FIG. **9** is a block diagram of zero-knowledge encryption **900** of digital content, consistent with various embodiments. In some embodiments, the zero-knowledge encryption **900** can be implemented in the environment **100** of FIG. **1**. The data management platform **110** encrypts the digital content associated with the user **135** prior to backing them up to the server **120** so that the digital content stored at the server **120** is secure. In some embodiments, the data management platform **110** performs the encryption using zero-knowledge encryption **900**, which means that the digital content is stored at the server **120** in an encrypted bundle and the server **120** has no knowledge of the encrypted contents of the encrypted bundle since the server **120** does not have access to an encryption key used for encrypting the digital content at the user device **105**.

[0104] In the zero-knowledge encryption **900** of FIG. **9**, digital contents of two users, such as user A **905** and user B **910** are encrypted. The user A **905** uploads a first digital content **925** from a user device **914**, and user B **910** uploads a second digital content **920** from a user device **915**. In some embodiments, the users **905** and **910** are similar to user **135** of FIG. **1** and the user devices **914** and **915** are similar to user device **105** of FIG. **1**. Further, each of the user devices **914** and **915** can have a copy of the data management platform **110** installed and executing at the corresponding user device. The first digital content **925** and the second digital content **920** are both of content type "car" and therefore, associated with a car universal data scaffold, such as the car universal data scaffold **305** of FIG. **3**.

[0105] The data management platform **110** stores the digital contents as a graph database in which the digital contents are represented as nodes of the graph. A node can be implemented as a data structure that contains the digital content, attribute values of the digital content, and an edge that connects the node to another node. An edge can be implemented as a data structure that contains the two nodes, which the edge connects, as the attributes of the edge data structure.

[0106] In backing up the first digital content **925** to the server **120**, the data management platform **110** at the user device **914** encrypts a first node corresponding to the first digital content **925**, e.g., using an encryption key, to generate a first encrypted bundle **930**. The first encrypted bundle **930**, which is typically a blob, includes the car universal data scaffold **305** associated with the first digital content **925**, and user data **940** associated with the first digital content **925**. The user data **940** includes an encrypted version of the first digital content **925** (e.g., if the first digital content **925** is an image file having a picture of a car, then encrypted version of the image file), including encrypted version of the attribute values of the first digital content **925**, e.g., "Acura," "MDX," "2017," and "2342342." The first encrypted bundle **930** is then transmitted to the server **120** for storage at the data storage system **125**, e.g., in a storage block **950** allocated to user A **905**. The encryption is done at the user device **914**, e.g., using an encryption key that only the user device **914** has access to. Since the server **120** would not have access to the encrypted key used the by the user device **914** in encrypting the first digital content **925**, the first encrypted bundle **930** cannot be decrypted at the server **120**, therefore making the digital content secure at the server **120**.

[0107] Similarly, the data management platform **110** at the user device **915** encrypts a second node corresponding to the second digital content **920**, using an encryption key whose access is restricted to the user device **915**, to generate a second encrypted bundle **935**. The second encrypted bundle **935** includes the car universal data scaffold **305** associated with the second digital content **920**, and user data **945** associated with the second digital content **920**, such as an encrypted version of the second digital content **920** and attribute values of the second digital content **920**, e.g., "Jeep," "Cherokee," "2016," and "3H3FJS." The second encrypted bundle **935** is transmitted to the server **120** for storage at the data storage system **125**, e.g., in a storage block **955** allocated to user B **910**.

[0108] Note that while the user data can be different for different users for digital contents of the same type, the car universal data scaffold included in the two encrypted

bundles are the same as the car universal data scaffold is common across all users of the data management platform **110**.

[0109] FIG. **10** is a block diagram of an example **1000** of storing encrypted bundles in the data management platform **110** and the server **120**, consistent with various embodiments. In some embodiments, the example **1000** can be implemented in the environment **100** of FIG. **1**, and using the zero-knowledge encryption **900** of FIG. **9**. As described above, the data management platform **110** can store the digital content in a graph database as nodes and edges. For example, the five digital contents depicted in the decrypted representation **1010**, which can be similar to the graph **700** of FIG. **7**A, are stored as five nodes with node identifiers n1-n5 and the four relationships between the nodes are stored as four edges with edge identifiers e1-e4 in a cache memory of the user device **105**.

[0110] When the user device **105** is synchronized with the server **120**, the nodes and edges are encrypted to generate encrypted bundles, and then transmitted to the server **120** for storage as encrypted bundles. In the example **1000**, the storage block **950** at the server **120**, e.g., more specifically at the data storage system **125** associated with the server **120**, stores the encrypted bundles of all the digital content associated with the user **135**.

[0111] Although the data management platform **110** backs up the encrypted bundles from the user device **105** to the server **120**, the data management platform **110** can store encrypted bundles of a subset of the digital content of the user **135** on the user device **105**. The example **1000** illustrates a node store **1005** on the user device **105** which stores the encrypted bundles having identifiers en1-en5 corresponding to the nodes n1-n5, respectively, and encrypted bundles having identifiers ee1-ee5 corresponding to the edges e1-e4, respectively (not all encrypted bundles of the nodes n1-n5 and edges e1-e4 are illustrated in the figure). The user device **105** can also have a key store **1015**, which stores a mapping of the node identifiers to the encrypted bundle identifiers, and a mapping of the edge identifiers to the encrypted bundle identifiers.

[0112] In some embodiments, the data management platform **110** determines the subset of the digital content to be stored at the user device **105**, e.g., based on the context associated with the user **135** as described at least with reference to FIG. **7** above, and stores the encrypted bundles of the selected subset.

[0113] In some embodiments, the data management platform **110** generates a separate encrypted bundle for each node and edge. By generating separate encrypted bundles for each node and edge, the data management platform **110** facilitates efficient retrieval of the digital content from the server **120**, e.g., retrieving one or more digital contents that are requested as opposed to being restricted to retrieving the digital contents as a group regardless of whether or not all digital contents in the group are requested. Such an efficient retrieval minimizes (a) the storage space consumed at the user device **105**, (b) the network bandwidth consumed in the retrieval, and (c) the time consumed in retrieving the required digital content.

[0114] FIG. **11** is an example **1100** illustrating zero-knowledge data retrieval from the server **120**, consistent with various embodiments. In some embodiments, the example **1100** may be implemented in the environment **100** of FIG. **1**. Consider that the server **120** stores the encrypted bundles of digital content corresponding to the graph representation **1105**. That is, the server **120** is storing encrypted bundles en1-en5 of the digital content represented by the nodes n1-n5, respectively, and encrypted bundles ee1-ee4 of the relationships represented by the edges e1-e4, respectively.

[0115] In a first phase **1110**, the data management platform **110** fetches a subset of the digital content as seed records, which are the digital content to be displayed by default in the GUI **115** or the digital content which the user may shortly request to access. In some embodiments, the seed records can be determined based on the context associated with the user **135**, e.g., as described at least with reference to FIG. **7** above. In some embodiments, the encrypted bundles of the seed records are retrieved from the server **120** and stored at the user device **105** regardless of whether the user **135** requests those seed records. In the example **1100**, consider that data management platform **110** determines digital content represented by nodes n1 and n3 as seed records, and therefore, retrieves the encrypted data **1120**, which includes encrypted bundles, en1 and en3, of the nodes n1 and n3, and encrypted bundle, ee2, of edge e2. The data management platform **110** decrypts **1125** the encrypted data **1120** to generate the nodes n1, n3 and edge e2. When the user **135** accesses the GUI **115** to view the digital contents, the data management platform **110** displays the nodes n1, n3 and the edge e2 connecting the nodes n1 and n2 in the GUI **115**. The first phase **1110** can be triggered at various instances, e.g., when the context associated with the user **135** changes.

[0116] In the second phase **1115**, which can be triggered when the user **135** requests for accessing one or more digital contents, the user **135** requests for a digital content corresponding to node n2. The data management platform **110** determines if the node n2 is available at the user device **105**, e.g., in the cache memory or the on-device storage. If the node n2 is available at the user device **105**, the data management platform **110** presents the digital content corresponding to the node n2 in the GUI **115**. On the other hand, if the node n2 is not available, the data management platform **110** determines the encrypted bundle identifier of the node n2, e.g., using the mapping stored in the key store **1015** of FIG. **10**, requests the server **120** to retrieve the encrypted bundle en2. After receiving the second encrypted data **1130**, which includes the encrypted bundle en2, the data management platform **110** decrypts **1135** the second encrypted data **1130** to generate the node n2. After decrypting the node n2, the data management platform **110** also retrieves the edge IDs of the edges e.g., edge e1, associated with the node n2, determines if those edges are available at the user device **105** (e.g., downloaded as part of seed records), and in the event they are not available, requests the server **120** to retrieve those edges as well. After the encrypted bundles of the edges are received, the data management platform **110** decrypts the encrypted bundles of the edges to generate the edges, e.g., edge e1, and then based on the information in the edge e1, the data management platform **110** connects the nodes n1 and n2 with the edge e1 in the GUI **115**.

[0117] FIG. **12** is a block diagram of an example **1200** for presenting offers to users of the data management platform, consistent with various embodiments. In some embodiments, the example **1200** may be implemented in the environment **100** of FIG. **1**. The data management platform **110** also facilitates zero-knowledge offers in which offers of goods and/or services are stored at user devices, e.g., as part of the universal data scaffolds **155**, but are displayed to those

users who satisfy a specified criterion, and an eligible user, if interested, may then accept, reject, or ignore the offer. Neither the server **120** nor a vendor, e.g., one of the third-party entities **145**, who has provided the offer may know to which users a specified offer was displayed until a user accepts the specified offer. In some embodiments, a zero-knowledge offer is an offer that may only be known to the user to whom the offer was displayed until acceptance. An offer just resides on the user devices until the criterion for displaying the offer is satisfied, which is when the offer is presented to the user. No privacy or security of the users are compromised from the zero-knowledge offers. The server **120** stores users' data as encrypted bundles **1215**, which can be similar to the encrypted bundles **930** and **935**, the contents of which are not readable either by the server **120** or the vendors.

[0118] The server **120** receives offers from vendors, e.g., the third-party entities **145**, such as an offer **1205** for an extended warranty for a car, to be presented to multiple users of the data management platform **110**. The offer **1205** can also include a vendor-defined criterion **1210**, which defines the criterion for displaying the offer **1205** to a user. For example, the vendor-defined criterion **1210** can indicate that the offer **1205** is to be presented to users having a car that is older than a specified year, e.g., 2018. In some embodiments, the server **120** redefines or reformulates the vendor-defined criterion **1210** to be compliant with the definition of universal data scaffolds **155**. For example, the server **120** can incorporate the appropriate attribute of the car universal data scaffold **305**, such as "carUDS. YEAR<2018," in which "carUDS" is the identifier of the car universal data scaffold and "YEAR" is the attribute of the car universal data scaffold **305** in the criterion **1210** to generate a server-defined criterion **1220**. Note that the above syntax is just for illustration and various other forms of representation may be used for generating the server-defined criterion **1220**. Further, note that the criterion for displaying the offer can be based on attributes of multiple digital contents, and is not restricted to attributes of just one digital content. The server **120** then generates a program code **1235** having the offer **1205** and the server-defined criterion **1220**, and includes the program code **1235** as part of the car universal data scaffold **305**.

[0119] When the users install the data management platform **110** on their user devices, e.g., by downloading the data management platform app to the user device, the universal data scaffolds **155** are downloaded to and stored at the user devices. So, the program code having the offers would also be stored on the user devices as part of the universal data scaffolds **155**. For example, the program code **1235** having the offer **1205** will be stored as part of the car universal data scaffold **305** at the user devices. The program code **1235** is executed in the data management platform **110** at the corresponding user devices. For example, the user device **105** executes the program code **1235** in the data management platform **110**. Upon execution, the program code **1235** monitors the attribute values of the first digital content **925** to determine if the first digital content **925** satisfies the server-defined criterion **1220**, and in an event the attribute values satisfy the server-defined criterion **1220**, the program code **1235** presents the offer **1205** to the user **135** in the GUI **115**. For example, the program code **1235** determines that the attribute value of the attribute YEAR in the first digital content **925**, which is "2017" is less than "2018," and therefore, satisfies the server-defined criterion **1220**.

[0120] The user **135** can choose to accept, reject, or ignore the offer **1205**. If the user **135** chooses to accept the offer **1205**, a response **1225** indicating the acceptance is sent from the user device **105** to the server **120**. The server **120** can forward the response **1225** as an acceptance **1230** of the offer **1205** to the vendor of the offer **1205**. The server **120** or the vendor may not know until the user **135** has accepted the offer if the offer **1205** was displayed to the user **135**, or to which the users the offer **1205** was displayed. In some embodiments, even after the user **135** accepts the offer **1205**, the data management platform **110** may anonymize the response **1225**, e.g. by removing some or all user identification information of the user **135**, before transmitting the response **1225** to the server **120**, which may be forwarded as an acceptance **1230** to the vendor. However, in some embodiments, some user identification may be necessary by the server **120** to have the offer **1205** serviced by the vendor. In such cases, the response **1225** may not be anonymized but the acceptance **1230** which is forwarded to the vendor may be anonymized. In some embodiments, some user identification may be necessary either by the server **120** or the vendor to honor the offer **1205**, and in such cases, user identification information may be transmitted with the acceptance **1230** to the vendor, but after obtaining permission from the user **135** to share the user identification information with the vendor.

[0121] In some embodiments, the data management platform **110** or the server **120** may anonymize the offer **1205**, e.g., by removing identification information of the vendor, before presenting the offer **1205** to the user.

[0122] In some embodiments, the server **120** can receive multiple offers for the same service or a product from multiple vendors. The server **120** can define an offer-selection criterion to select an offer from the multiple competing offers, determine the offer that satisfies the offer-selection criterion, and include the selected offer, e.g., as program code, in the corresponding universal data scaffold. In some embodiments, the server **120** can select more than offer to be included in the universal data scaffold. For example, the server **120** can include a first competing offer and a second competing offer in which the first competing offer is presented if a first criterion is satisfied and the second competing offer is presented if a second criterion is satisfied.

[0123] The offers, which are part of the universal data scaffolds **155**, are typically stored at the user devices when the users install the data management platform **110** on their corresponding user devices. However, in some embodiments, the offers can also be transmitted to the users at other times. For example, when the offers are updated, such as new offers are received by the server **120**, criterion of an existing offer changes, or some existing offers are not valid anymore, the server **120** updates the universal data scaffolds of which the updated offers are a part, and transmits the updates to the universal data scaffolds to the users, e.g., as part of an app update. The transmission of the app update to the user devices are triggered based on one or more conditions, e.g., based on a specified time interval such as daily basis or weekly basis; or when the user **135** opens the data management platform **110** app on the user device **105**.

[0124] As described at least with reference to FIG. **8**, because the digital content is stored as structured data using the universal data scaffolds, various types of intelligence can

be derived by performing various analyses of the digital content, and such intelligence can be used to make relevant offers to the users. For example, if the server **120** determines that a particular user, e.g., a parent stores digital content associated with a child and various profiles of a nanny, the server **120** may send offers for background check services to the parent. When the parent opens a profile associated with the child's nanny, the data management platform **110** may present an offer to order a background check if no background check has been performed for the nanny yet.

[0125] FIG. **13** is a block diagram of the data management platform **110** of FIG. **1**, consistent with various embodiments. The data management platform **110** includes components such as a data transceiver component **1305**, a data scaffold component **1310**, an attribute value determination component **1315**, a data storage component **1320**, a GUI component **1325**, an encryption component **1330**, and offer management component **1335**. The functionalities of the above components are described at least with reference to FIGS. **15-19** below.

[0126] Note that the data management platform **110** may include some or all of these components, as well as other components not shown in FIG. **13**. For example, the data management platform **110** can include lesser number of components, e.g., functionalities of two components can be combined into one component, or can include more number of components, e.g., components that perform other functionalities. In some embodiments, the functionalities of one or more of the above components can be split into two or more components. In some embodiments, the data management platform **110** resides on the user device **105**. In some embodiments, the data management platform **110** resides on the server **120**. In some embodiments, the data management platform **110** can be distributed across the server **120** and the user device **105**. Those skilled in the art will recognize that the components of the data management platform **110** can be distributed between the server **120** and the user device **105** in various manners.

[0127] FIG. **14** is a block diagram of the server **120** of FIG. **1**, consistent with various embodiments. The server **120** includes components such as a data transceiver component **1405**, an offer management component **1410**, and a data storage component **1415**. The functionalities of the above components are described at least with reference to FIGS. **15-19** below.

[0128] Note that the server **120** may include some or all of these components, as well as other components not shown in FIG. **14**. For example, the server **120** can include lesser number of components, e.g., functionalities of two components can be combined into one component, or can include more number of components, e.g., components that perform other functionalities. In some embodiments, the functionalities of one or more of the above components can be split into two or more components. Further, the components can be implemented at a single server device or distributed across server devices.

[0129] FIG. **15** is a flow diagram of a process **1500** for performing data management operations on the digital contents associated with a user in a data management platform. In some embodiments, the process **1500** can be implemented in the environment **100** of FIG. **1**. At block **1501**, the data management platform **110** is launched on the user device **105**. For example, the data management platform **110** is an app running on the user device **105**. The data management platform **110** can a communication link to be established with a server **120** via network **130**.

[0130] At block **1502**, the data transceiver component **1305** receives a digital content, such as a picture of a car or a bill of sale of the car, uploaded by the user **135** using the GUI **115**. For example, the user **135** may select the digital content from a local storage on the user device **105** or from another digital content source **140** such as a file hosting service (e.g., Dropbox®, Google Drive®, or Microsoft OneDrive®) that interfaces with the data management platform **110** (e.g., via an API).

[0131] At block **1503**, the data scaffold component **1310** maps the digital content to one of the content types defined in the data management platform **110**. The data scaffold component can determine the content type using any of the multiple methods described at least with reference to FIG. **5** above. For example, the data scaffold component **1310** can identify the content type based on the input fields used in the GUI **115** to enter the digital content. In another example, the data scaffold component **1310** can automatically analyze the digital content, e.g., using OCR, and determine the content type based on machine learning techniques and/or deductive inference rules. In still another example, the data scaffold component **1310** can prompt the user **135** to identify the content type from a list of content types.

[0132] At block **1504**, after determining the content type, the data scaffold component **1310** retrieves a universal data scaffold corresponding to the identified content type, which defines the content type using a set of attributes and metadata (such as rules). For example, if the content type is identified as a "car," then the data scaffold component **1310** retrieves the car universal data scaffold **305** from the data management platform **110**.

[0133] At block **1505**, the attribute value determination component **1315** identifies the set of attributes defined in the universal data scaffold and analyzes the digital content to obtain values for the set of attributes. For example, the attribute value determination component **1315** can identify the set of attributes defined in the car universal data scaffold as make, model, year, and VIN. The attribute value determination component **1315** can analyze the digital content, e.g., using OCR, to obtain the attribute values for the above attributes, and/or prompt the user **135** to input all or some of the attribute values.

[0134] At block **1506**, the data storage component **1320** stores the digital content in a structured format, e.g., along with the attribute values and the universal data scaffold of the digital content, in the user device **105**. In some embodiments, the data storage component **1320** stores the digital content as a graph database in which the digital contents are represented as nodes of the graph and a relationship between the digital contents as an edge between the corresponding nodes.

[0135] At block **1507**, the GUI component **1325** generates a GUI to present the digital contents to the user **135** on the user device **105**. For example, the GUI component **1325** generates a graphical representation **750** that displays the digital contents. In some embodiments, the information regarding the digital content presented in the graphical representation **750** may be obtained from the graph **700**. The GUI component **1325** retrieves the digital contents to be displayed in the graphical representation **750** from the node store **1005** of the user device **105**, or from the server **120** in an event they are not available in the node store **1005**.

[0136] The digital contents stored at the user device **105** are typically backed up to the server **120** for archiving. At block **1508**, the data storage component **1320** can synchronize the user device **105** with the server **120** to back up the digital contents from the user device **105** to the server **120**. The data storage component **1415** of the server **120** can store the backed up digital contents at the data storage system **125**. In some embodiments, in the synchronization process, the data transceiver component **1305** transmits only those digital contents that are not yet backed up to the server and/or the digital contents that have been modified at the user device **105**.

[0137] FIG. **16** is a flow diagram of a process **1600** for displaying the digital contents on the user device, consistent with various embodiments. In some embodiments, the process **1600** may be implemented in the environment **100** of FIG. **1**. At block **1605**, the data transceiver component **1305** receives a request from the user **135** for downloading digital contents associated with the user **135** from the server **120**. The user **135** can issue such a request using the GUI **115**.

[0138] At block **1610**, the data transceiver component **1305** downloads at least some of the digital contents from the server **120** to the user device **105**. In some embodiments, the number of digital contents downloaded can be determined based on a total number of digital contents stored at server **120** that are associated with the user **135** and a memory space available for storing the digital contents at the user device **105**. In some embodiments, the digital contents that are downloaded can be selected by the data transceiver component **1305** based on a context associated with the user **135**. The downloaded digital contents can be stored in the node store **1005**. When the downloaded contents are stored in the node store **1005**, some of the digital contents that are already stored in the node store **1005** may be removed from the node store **1005** to accommodate the downloaded digital contents.

[0139] At block **1615**, the data storage component **1320** retrieves a first digital content from the downloaded digital contents, e.g., based on the context associated with the user **135**.

[0140] At block **1620**, the data storage component **1320** retrieves a set of digital contents that are related to the first digital content. For example, the data storage component **1320** can inspect the node corresponding to the first digital content to obtain the edges of the node, and then inspect each of the edges to determine the other node to which the node is connected, thereby determining the set of digital contents that is related to the first digital content.

[0141] At block **1625**, the GUI component **1325** generates a graphical representation of the first digital content and the set of digital contents based on the nodes and edges determined in block **1620**. For example, the graphical representation can be similar to the graphical representation **750** of FIG. **7**B.

[0142] FIG. **17** is a flow diagram of a process **1700** for performing zero-knowledge encryption of the digital contents in the data management platform, consistent with various embodiments. In some embodiments, the process **1700** may be implemented in the environment **100** of FIG. **1**. At block **1705**, the data transceiver component **1305** receives multiple digital contents from the user **135**. For example, the user **135** may upload the digital contents using the GUI **115**.

[0143] At block **1710**, the data storage component **1320** stores the digital components at the user device **105**, e.g., in the node store, as a graph database in which the digital contents are represented as nodes of the graph and a relationship between the digital contents as an edge between the corresponding nodes.

[0144] At block **1715**, the encryption component **1330** encrypts a first node corresponding to a first digital content to generate a first encrypted bundle of the first node. The encryption component **1330** also packages a first universal data scaffold with which the first digital content is associated in the first encrypted bundle. That is, the first encrypted bundle can include the first universal data scaffold and an encrypted version of the first digital content, including the attribute values of the attributes of the first digital content. The attributes are defined by the first universal data scaffold. The data storage component **1320** can store the first encrypted bundle in the node store **1005**. The encryption component **1330** encrypts the first node using an encryption key that is typically accessible or available only at the user device **105**. The encryption key can also be used for decrypting the first encrypted bundle to extract the first digital content. The encryption component **1330** can use any of multiple encryption techniques for performing the encryption.

[0145] At block **1720**, the data transceiver component **1305** transmits the first encrypted bundle to the server **120** for storage at the data storage system **125**. The data storage component **1415** of the server **120** receives the first encrypted bundle and stores it at the data storage system **125**. In some embodiments, the data transceiver component **1305** transmits the first encrypted bundle to the server **120** when the user device is synchronized with the server **120**.

[0146] FIG. **18** is a flow diagram of a process **1800** for decrypting the digital contents in the data management platform, consistent with various embodiments. In some embodiments, the process **1800** can be implemented in the environment **100** of FIG. **1**. At block **1805**, the data transceiver component **1305** receives a request for a specified digital content from the user **135**.

[0147] At determination block **1810**, the data storage component **1320** determines whether the specified digital content is available at the user device **105**. For example, the data storage component **1320** can determine if a specified node corresponding to the specified digital content, or if a specified encrypted bundle corresponding to the specified node, is available in the node store **1005**.

[0148] In an event either the specified node or the specified encrypted bundle is available at the user device **105**, the process proceeds to block **1820**. On the other hand, if the data storage component determines that neither the specified node nor the specified encrypted bundle is available at the user device **105**, at block **1815**, the data transceiver component **1305** retrieves the specified encrypted bundle from the server **120**. For example, the data storage component **1415** of the server **120** can retrieve the specified encrypted bundle from the data storage system **125** and the data transceiver component **1405** at the server **120** can transmit it to the data transceiver component **1305**.

[0149] At block **1820**, the encryption component **1330** decrypts the specified encrypted bundle to extract (a) the specified node, which includes the specified digital content and its attribute values, and (b) a specified universal data scaffold corresponding to the specified digital content.

[0150] At block **1825**, the GUI component **1325** generates a graphical representation of the specified node in the GUI **115**, which corresponds to the specified digital content. The graphical representation can be similar to the graphical representation **750** of FIG. **7**B. The graphical representation **750** can display the attributes and attribute values associated with the specified digital content. The attributes of the specified node are determined based on the specified universal data scaffold associated with the specified digital content.

[0151] FIG. **19** is a flow diagram of a process **1900** for sending zero-knowledge offers to the users of the data management platform **110**, consistent with various embodiments. In some embodiments, the process **1900** can be implemented in the environment **100** of FIG. **1**. At block **1905**, the data transceiver component **1405** at the server **120** receives a specified offer from a vendor for presenting to users of the data management platform **110**. The specified offer can also include information such as a criterion for presenting the specified offer to the users. Typically, an offer is associated with or relevant to a specified content type. For example, an offer for extended warranty for a car is associated with the content type "car."

[0152] At block **1910**, the offer management component **1410** determines a universal scaffold, that is, the content type, with which the specified offer is to be presented. In some embodiments, the offer management component **1410** can analyze the data associated with the specified offer to determine the content type to which the offer is relevant. The offer management component **1410** can automatically analyze the specified offer, e.g., using OCR, and determine the content type based on machine learning techniques and/or deductive inference rules, or obtain the content type from the vendor.

[0153] At block **1915**, the offer management component **1410** generates a program code for presenting the specified offer to the users. The program code includes the specified offer and a server-defined criterion for presenting the specified offer to the users. The server-defined criterion is generated by redefining or reformulating the vendor-provided criterion of the specified offer using the attributes of the universal data scaffold. For example, the offer management component **1410** can reformulate a vendor-defined criterion, which states that the specified offer is to be presented to users with cars that are of year "2017" or older, by incorporating the appropriate attribute of the car universal data scaffold to generate the server-defined criterion, such as "carUDS.YEAR<=2017," in which "carUDS" is the identifier of the car universal data scaffold and "YEAR" is the attribute of the car universal data scaffold.

[0154] The program code can be an executable code that can be executed at the user devices. The program code is also configured to monitor the attribute values of the digital content for which the specified offer is to be presented.

[0155] At block **1920**, the offer management component **1410** stores the program code as part of the universal data scaffold. When the users install the data management platform **110** at their corresponding user devices, the universal data scaffold is stored at the user devices. Because the universal data scaffold is same for all users of the data management platform **110**, all the users will have the same specified offer stored in their corresponding user devices.

[0156] FIG. **20** is a flow diagram of a process **2000** for displaying the zero-knowledge offers to the users of the data management platform **110**, consistent with various embodiments. In some embodiments, the process **2000** can be implemented in the environment **100** of FIG. **1**. At block **2005**, the offer management component **1335** executes a program code stored as part of a universal data scaffold at the user device **105**. The program code includes a specified offer that is to be presented to the user **135** in association with a digital content at the user device **105**.

[0157] At block **2010**, the offer management component **1335** executes the program code to monitor attribute values of the digital content for which the specified offer is to be presented.

[0158] At determination block **2015**, the offer management component **1335** determines whether the attribute values satisfy the server-defined criterion in the program code.

[0159] If the attribute values do not satisfy the server-defined criterion, the process continues to monitor the attribute values (block **2010**). In an event the attribute values satisfy the server-defined criterion, at block **2020**, the offer management component **1335** presents or displays the specified offer to the user **135**.

[0160] At determination block **2025**, the offer management component **1335** determines whether the user **135** accepted the specified offer. In an event the user accepted the specified offer, at block **2030**, the data transceiver component **1305** transmits a response to the server **120** indicating an acceptance of the specified offer. In some embodiments, the response may be anonymized, e.g., by removing some or all of user identification information, prior to transmitting the response to the server **120** to preserve the privacy of the user **135**.

[0161] In an event the user **135** has not accepted the specified offer, e.g., rejected or ignored, the process **2000** returns.

[0162] FIG. **21** shows a universal scaffolding data structure partially stored on a user device. Device **2100** can be a user device, such as a mobile phone, and can have more limited resources than the device **2110**, which can be a server. Consequently, only a portion of the universal scaffolding data structure **2120** can be stored on the user device **2100**, while the remote device **2110** can store the full universal scaffolding data structure **2120**. In some cases, the full universal scaffolding data structure **2120** can be downloaded on the user device **2100**.

[0163] A private database can include information such as make and model of user's car, user's address, number of children, etc. A public database can include information such as size of the house, size of the yard, phone number, etc. The private database can exist unencrypted on the user device **2100** and can contain the user's information. An encrypted version of the private database can exist on the server **2110**. Because the private database is encrypted on the server **2110**, the server does not have the knowledge of the user's private data, and consequently the user's privacy is protected.

[0164] The universal scaffolding data structure **2122** can be initialized upon receiving data from a user when the user is engaged in a structured workflow, such as when a user is applying for automotive insurance. For example, the user can upload an insurance form for an automotive insurance policy. The user device **2100** can receive the insurance form and convert the insurance form into the universal scaffolding data structure **2122** by extracting data from the insurance

form and populating the universal scaffolding data structure **2122** with the received data. In addition, the data that is not available in the automotive insurance form but is usually associated with vehicle owners can also be initialized in the universal scaffolding data structure **2122**. For example, a driver's license field may not be available in the insurance form, but the driver's license node **2126** can be initialized with an empty driver's license value, because there is a high correlation between people who apply for automotive insurance and the existence of a driver's license.

[0165] Similarly, whenever a person creates a node in the universal scaffolding data structure **2120**, whether that node is the root of the whole universal scaffolding data structure **2120**, such as node **2130**, or is a node in the universal scaffolding data structure **2120**, such as **2150**, the system can create all nodes that are likely to be associated with the newly created node.

[0166] In addition, the user can opt in to a creation of a subgraph, such as subgraph **2180**, without the system automatically creating the subgraph **2180**. For example, the user may be a cancer survivor, and may have information related to the disease such as an effective therapy. In another example, the user can have a heart condition and may want to know if the user at risk for a heart attack. The user device **2100** can offer to perform an analysis of the user's data **2180** using algorithms that can be developed by third-party entities, such as research universities or research labs. Upon the analysis, the system can make a recommendation to the user such as the user needs to measure blood pressure twice a day and follow a particular diet. The whole subgraph **2180** or a portion of the subgraph **2180** can be stored in the user device **2100**.

[0167] When storing a portion of the universal scaffolding data structure **2120** on the user device **2100**, the user device **2100** can decide whether to pay a cost for storage space on the user device **2100** or for network data bandwidth or download time when a portion of the universal scaffolding data structure **2120** needs to be downloaded from the remote device **2110**.

[0168] For example, the user device **2100** can store one node **2130**, while the universal scaffolding data structure **2120** can be stored on the remote device **2110** in encrypted form. When the user device **2100** wants to access node **2140** that is currently not stored in the user device **2100**, the user device **2100** can download the node **2140** from the remote device **2110**, without the user being aware of the location of the node **2140**.

[0169] The system can receive an input from the user expressing preference about how much space the user would like to devote to the universal scaffolding data structure **2122** stored on the local device **2100**. The system can take that input into account and can also utilize a prioritization scheme for determining whether data stored on the user device **2100** can be evicted aggressively versus whether the data should be kept on the user device **2100** to help with performance. For example, if the network **2190** is slow, the system can keep the data on the user device **2100**, while if the network **2190** is not slow and the user device **2100** has reached the storage limit, the system can evict the data from the user device **2100**. The decision whether to store the data on the user device **2100** or to evict it can be performed dynamically based on the network **2190** conditions as well as the user device **2100** conditions.

[0170] In one embodiment, the user device **2100** can prefetch the data that would be necessary for all the possible navigations, or the system can anticipate a likely navigation based on the current navigation. When prefetching the data, the user device **2100** can download the nodes from the remote device **2110**. For example, if the user is interacting with the data at the node **2150**, the system can anticipate that the user is likely to browse nodes **2160** and **2170**, and prefetch those two nodes from the remote device **2110**.

[0171] In another embodiment, the system can predict information likely to be relevant to the user and can prefetch nodes from the remote device **2110** that are related to the information. For example, if the user's birthday is coming up within the next week, the system can prefetch nodes containing information about the user's favorite activities such as frequented restaurants, frequented entertainment locations, etc.

[0172] FIG. **22** shows a system to preserve a user's privacy by providing bundled answers. When a user device **2200** interacts with a remote device **2210**, such as a server, a cloud computer, etc., the user device **2200** can request information, such as nearby restaurants, entertainment in Chicago, etc. When the remote device **2210** provides the requested information, the provision of information can violate the user's privacy by indicating the user's location. For example, when the answer contains restaurants within a 5 mile radius, a third party can infer that the user is within the 5 mile radius, or if the information contains restaurants in Chicago, the third party can infer that the user is in Chicago.

[0173] To protect the user's privacy, the remote device **2210** can provide bundled answers **2220**, which, in addition to the answer **2230** that the user requested, contain additional answers **2240** intended to mask the actual answer the user is looking for. The additional answers **2240** are consistent over time, so that if the user repeatedly asks the same question, the additional answers **2240** do not change while the true answer **2230** remains the same, thus preventing the third party from inferring that the true answer **2230** is the one that is same across multiple bundled answers **2220**.

[0174] For example, if the user at time T**1** asks the question **2250**, and at a later time T**2** asks the same question **2250**, the variation between the answer **2230** and answer **2232**, and the additional answer **2240** and answer **2242** should be substantially the same. For example, if the answers **2230** and **2232** are the same, the additional answers **2240** and **2242** are the same. If the answers **2230** and **2232** vary by, for example, one entry (e.g. one restaurant), the additional answers **2240** and **2242** can vary by a proportionate amount, such as one entry. That way, the third party receiving the bundled answers **2220**, **2222** cannot isolate the answer **2230**.

[0175] FIG. **23** shows a query resolution between a user device and the server using bundled data. The server **2300** and the user device **2305** can communicate via a wireless or a wired network. The user device **2305** can send a query to the server **2300**, and the server can send a bundle **132**, **1098** containing an answer to the query. The server **2300** can include multiple bundles **132**, **1098** of data containing a data structure associated with a universal data scaffold, as described in this application.

[0176] The universal data scaffold can include various types of data structures and relationships between data structures. A type of data structure can correspond to an

information topic contained in the data structures, such as restaurants, medical information, vehicle information, etc. The bundles **132**, **1098** of data can include information on various disparate topics stored in one or more of the data structures included in the universal data scaffold. Each bundle **132**, **1098** can contain hundreds or thousands of data structures **2310**-**2370**.

[0177] For example, bundle **132** can include data structure **2310** containing information about restaurants in Chicago, data structure **2320** containing information about restaurants in Seattle, data structure **2330** containing information about courthouses in Washington DC, data structure **2340** containing information about public defenders in Minneapolis, etc. In another example, bundle **1098** can include data structure **2350** containing information about Manhattan fire stations, data structure **2360** containing information about asthma, data structure **2370** containing information about nail salons in Palo Alto, etc.

[0178] As can be seen in bundles **132**, **1098**, the data structures **2310**-**2370** can contain information on disparate topics to hide the true information that the user device **2305** is searching for. For example, the topics contained in the bundles **132**, **1098** vary, from restaurants to public defenders. The ownership of the services contained in the bundles **1032**, **1098** can include government as well as private ownership. For example, restaurants can be private, while the courthouses and public defenders are government services.

[0179] In another example, data structure **2360** containing information about asthma can be bundled with information about nail salons and Manhattan fire stations, instead of being bundled with data structures containing other medical information. Consequently, a potentially malicious third-party observer receiving information about bundles **132**, **1098** downloaded to the user device **2305** cannot conclude that a user of the user device **2305** has a medical condition.

[0180] To further obfuscate user information, the bundles **132**, **1098** can contain data structures **2310**-**2370** associated with disparate geographic locations, so that the third party cannot infer the location of the user device **2305** from the bundles downloaded to the user device **2305**. For example, the bundle **132** contains information about Chicago, Seattle, Washington and Minneapolis, while bundle **1098** contains information about Manhattan and Palo Alto.

[0181] The bundles **132**, **1098** can contain overlapping information. For example, data structure **2310** can be contained in both bundles **132**, **1098**.

[0182] The server **2300** can include a table of contents data structure **2380** that creates a mapping between the bundle ID, such as **132**, **1098**, and information contained in the bundle. For example, data structure **2390** in the table of contents data structure **2380** includes bundle ID **132** and the topics contained in the bundle **132** such as restaurants in Chicago, restaurants in Seattle, courthouses in Washington DC, and public defenders in Minneapolis. Data structure **2395** in the table of contents data structure **2380** includes bundle ID **1098** and the topics contained in the bundle such as Manhattan fire stations, information about asthma, nail salons and Palo Alto.

[0183] The server **2300** can send the table of contents data structure **2380** to the user device **2305**. When the user device **2305** receives a query **2315** from the user, the user device can determine a topic of the query, and, based on the topic of the query, the user device can search the table of contents data structure **2380** to determine the bundle ID that contains information about the topic.

[0184] Once the user device **2305** determines the bundle ID, the user device sends a query **2325** to the server **2300** containing the bundle ID. Consequently, the server does not have access to the user query **2315**. Further, because the bundles **132**, **1098** include information on disparate topics, the server **2300** does not have access to the topic of the query **2325** and cannot infer information about the user such as his location, his interests, his medical condition, etc. Similarly, the potentially malicious third-party observing the interaction between the server **2300** and the user device **2305** cannot gain information about the user. The communication between the server **2300** and the user device **2305** can be encrypted, further deterring an unauthorized third-party. However, even if the third party compromises the server and gains access to the server log containing information about interactions between the server **2300** and the user device **2305**, the third party cannot obtain information about the user because information is not available on the server **2300**.

[0185] FIG. **24** is a flowchart of a method to provide an answer to a query generated by a user device by hiding the answer and the query from a server providing the answer. In step **2400**, a processor can create a universal data scaffold defining multiple data structures and multiple relationships among the multiple data structures. A data structure in the universal data scaffold can be a node in a graph while a relationship can be an edge in a graph, as explained herein. The universal data scaffold can represent information in a structured way, as explained herein. The data structure can include a portion of the information. For example, the information contained in the universal data scaffold can be public information contained on the Internet. A data structure, which is a part of the universal data scaffold, can contain a portion of the information, such as information about Toyota Camry cars, medical treatments for asthma, Chicago restaurants, etc. The server **2300** in FIG. **23** can distribute at least a portion of the universal data scaffold to the user device **2305** in FIG. **23**.

[0186] In step **2410**, the processor can create multiple bundles, such as bundles **132**, **1098** in FIG. **23**. Each bundle can include two or more data structures among the multiple data structures, where the data structures in the bundle can be the same type or can be of different types. A data structure type can correspond to the information topic contained in the data structures, such as restaurants, museums, vehicle information, etc. For example, data structures **2310** and **2320** in FIG. **23** have the same type corresponding to the topic of restaurants.

[0187] To create the multiple bundles, the processor can obtain the two or more data structures including a first data structure and a second data structure. A first portion of the information contained in the first data structure can be associated with a first topic, and a second portion of the information contained in the second data structure can be associated with the second topic, where the first topic and the second topic are unrelated. The processor can create a bundle using the first and the second data structure.

[0188] The first topic and the second topic can be disparate based on type, based on location, based on granularity, etc. For example, the first topic can describe a commercial service, and the second topic can describe a government service. In another example, to vary the location, the first

topic and the second topic can include disparate geographic locations. More specifically, the first topic can relate to Oklahoma City, and the second topic can relate to New Orleans. Similarly, to vary the granularity, the first topic can relate to a state such as New Jersey, and the second topic can relate to a county such as Lafayette County.

[0189] In step **2420**, the processor can create a unique identifier (ID) for each bundle among the multiple bundles, such as ID **132**, **1098**.

[0190] In step **2430**, the processor can create a table of contents data structure **2380** in FIG. **23** indicating the unique ID of a bundle and the portion of the information contained in the two or more data structures included in the bundle.

[0191] In step **2440**, the processor can enable the user device **2305** in FIG. **23** to obtain, from a server **2300** in FIG. **23**, an answer to a query **2315** in FIG. **23**, without disclosing the query and the answer to the server. The processor associated with the server **2300** can send the table of contents data structure **2380** to a user device.

[0192] The processor associated with the server can provide an answer to the query **2315** from the user device **2305** by receiving an indication of the unique ID **132**, **1098** of the bundle. The processor can provide the bundle associated with the unique ID **132**, **1098** to the user device **2305**, without obtaining the query and the answer to the server, because the answer to the query is contained within the portion of the information contained in the bundle, and the bundle contains information on multiple disparate topics.

[0193] The processor can incorporate additional information into the universal data scaffold by, for example, obtaining trending topics through data mining. The processor can update the multiple bundles to contain the additional information and update the table of contents data structure to include the additional information and a unique ID of a bundle associated with the additional information. The processor can distribute the updated table of contents data structure to the user device, such as user device **2305**.

[0194] FIG. **25** is a flowchart of a method to protect user data by obtaining an answer to a query from a server, without disclosing the query and/or the answer to the server. In step **2500**, a processor associated with a user device can obtain, from a server, a universal data scaffold defining multiple data structures and multiple relationships among the multiple data structures. A data structure can be represented by a node in a graph, and a relationship can be represented by an edge in the graph.

[0195] The universal data scaffold can represent information in a structured way. For example, the information contained in the universal data scaffold can be public information contained on the Internet. A data structure, which is a part of the universal data scaffold, can contain a portion of the information, such as information about Toyota Camry cars, medical treatments for asthma, Chicago restaurants, etc. The public information represented by the universal data scaffold can be stored encrypted or unencrypted on the server **2300** in FIG. **23**.

[0196] The data structure, which is a part of the universal data scaffold, can also contain data associated with a user, such as the user's driver's license, the user's car make and model, the user's Social Security number, the user's health insurance, etc. For example, the user device can obtain data associated with the user, can structure the data associated with the user into a format compatible with the universal data scaffold, and can store the formatted data in the data structure. The data structure that contains sensitive user information can exist unencrypted only on the user device **2305** in FIG. **23**. The data structure containing the sensitive user information can be encrypted and sent to the server. Consequently, the server **2300** does not have access to the decrypted data.

[0197] In step **2510**, the processor associated with the user device can obtain from the server multiple bundles. Each bundle among the multiple bundles can include two or more data structures, such as a first data structure and a second data structure. The first and the second data structure can be of the same type, such as medical information, or they can be of different types that vary by topic, granularity, geographic location, etc. Information contained in the first data structure can be associated with a first topic, while information contained in the second data structure can be associated with the second topic, where the first topic and the second topic are unrelated.

[0198] In step **2520**, the processor associated with the user device can obtain from the server a table of contents data structure **2380** in FIG. **23** indicating a mapping between multiple unique identifiers (IDs) **132**, **1098** in FIG. **23** associated with the multiple bundles and multiple contents included in the multiple bundles. A unique ID among the multiple unique IDs corresponds to a bundle. Contents contained in the bundle can describe a topic of the information contained in the bundle.

[0199] In step **2530**, the processor associated with the user device can receive a query from the user. The query can be a natural language query and can be in a textual and/or an audio format.

[0200] In step **2540**, the processor can determine a content among the multiple contents corresponding to the query, and a unique ID of a bundle including the content, by, for example, finding a content among multiple contents providing an answer to the query. To determine the content corresponding to the query, the processor can find a closest match between the query and a content among multiple contents associated with the table of contents. The closest match can be closest semantic match.

[0201] For example, if the user query states "Italian restaurant nearby," the processor can perform a semantic match by determining the location of the user, such as Chicago. Based on the table of contents data structure **2380**, the processor can determine that the bundle having unique ID **132** contains an answer to the query, because bundle **132** contains information about restaurants in Chicago.

[0202] The processor can provide the content among the multiple contents having the closest match with the query as well as the ID of the bundle containing the content. If the bundle containing the content has been downloaded on the user device **2305**, the processor does not have to send a request for the bundle ID to the server. Further, the processor can check with the server **2300** whether an update to the bundle ID is available. If no update is available, the processor can provide the content of the bundle to the user, without downloading the bundle from the server.

[0203] In another embodiment, the server **2300** can communicate to the user device **2305** when a bundle **132**, **1098** has been updated. If the user device **2305** contains bundle **132**, **1098**, the user device can download the updated bundle.

[0204] In step **2550**, the processor associated with the user device can prevent the server from obtaining the query and an answer to the query by requesting the unique ID **132**

associated with the bundle including the content, without disclosing the query and the answer to the server. The server **2300** cannot determine the information that the user is looking for, because bundle **132** contains information about Chicago restaurants, Seattle restaurants, courthouses in Washington, public defenders in Minneapolis, etc.

[0205] Once the processor of the user device obtains the bundle having the unique ID from the server, the processor can find a data structure, in the bundle, that includes the content containing the answer to the query. The processor can reduce memory consumption associated with the user device by deleting, from the user device, other data structures associated with the bundle except for the data structure including the content comprising the answer to the query.

[0206] The processor can dynamically decide, based on memory of the user device and/or bandwidth of the channel between the user device and the server, whether to store information on the device or to request the information from the server at a future time.

[0207] In one embodiment, the processor of the user device can obtain from the server a bundle including a data structure, associated with the universal data scaffold, containing information on a topic and/or a data structure acting as a placeholder for currently unavailable information. For example, the data structure acting as the placeholder can contain the class definitions for a Tesla model S, but because the user doesn't have the Tesla model S, the user information in the data structure acting as the placeholder can be missing.

[0208] The processor can determine a first amount of a first resource associated with the user device which is consumed by at least a portion of the bundle, and a second amount of a second resource associated with the user device by the portion of the bundle. The portion of the bundle can include one or more data structures and/or one or more data structures acting as a placeholder for currently unavailable information. The first resource and the second resource can be memory of the user device, processing power of the user device, upload bandwidth, or download bandwidth between the user device **2305** and the server **2300**.

[0209] The processor can determine availability of the first resource associated with the user device and availability the second resource associated with the user device. The processor can also determine the likelihood that the user will access the portion of the bundle within a predetermined timeframe, such as an hour, a day or a week. In addition, the processor can take user preferences into account, as described in FIG. **21**. Based on the availability of the first resource associated with the user device and the availability of the second resource associated with the user device, the processor can determine whether to delete the portion of the bundle.

[0210] For example, the user device can have plenty of available memory, but can be in a location where the communication bandwidth between the user device and the server is low. The processor can decide to not delete the portion of the bundle.

[0211] In another example, the user device can be low on memory, but the communication bandwidth between the user device and the server can be high. The processor can decide to delete the portion of the bundle.

[0212] In a third example, the user device can be low on memory, the communication bandwidth between the user device and the server can be low, but the likelihood that the user will access the portion of the bundle within the next day is low. In this case, the processor can decide to delete the portion of the bundle because the likelihood that the user will need the portion of the bundle is low.

[0213] FIG. **26** shows a manner of accessing a password in a recall-memory enhancing manner. With a multitude of passwords in today's technologically enhanced world, where each password is a string of nonsensical alphanumeric characters, the user can easily forget a particular password. However, while users frequently forget a nonsensical password, users easily remember places, favorite songs, or other emotionally relevant items. The system disclosed here enables a user to access passwords in a recall-memory enhancing manner by tying password access to memorable items such as places, songs, images, or other emotionally relevant items.

[0214] In a preferred embodiment, a password set/reset capability is available based on a specific geographic location **2600**. The user has to be in the location **2600** to set the password and/or reset the password. The location **2600** could be anywhere: store, home, tree in a park, spot in a lake, etc. The geographic coordinates, such as latitude and longitude, of the location **2600** can be stored in the zero-knowledge database **700** in FIG. **7**. The geographic coordinates can be encrypted on the server but decrypted on the user device **2610**. When the user is within a certain radius of the geographic location **2600**, such as within 30 feet, the user can access the setting and/or resetting capabilities for the password.

[0215] In another embodiment, the user's geographic location can be determined in various ways. For example, the password set/reset capability can be unlocked when the user records an image containing predefined items, such as a particular tree and the birdfeeder, or a particular grandfather clock.

[0216] In a third embodiment, the password set/reset capability is available when a particular song is playing in the background, and/or when the user records a particular picture including specified elements. For example, if the picture includes a fireplace and a red carpet, the user device **2610** can enable the password set/reset capability. Initially, the user can specify the recall-memory enhancing items such as places, songs, photos, etc. The recall memory enhancing items can be stored in the zero-knowledge database **700** in FIG. **7**, and access to the recall-memory enhancing items can be further masked using bundled answers, as described in this application.

[0217] To specify the song, the user can provide the title of the song or can play the song on the user device **2610**. To specify the photo, the user can take a photo at the location and can circle one or more relevant objects in the photo. In one embodiment, to specify the geographic location, the user can go to the geographic location with the user device **2610** and indicate to the user device **2610** that the particular geographic location unlocks set/reset password capabilities.

[0218] To increase security, in addition to verifying the geographic location, the processor can require another authentication factor before enabling access to the password. For example, the second authentication factor can be a biometric measurement of the user, such as a retina scan, a face scan, a fingerprint, or a voice identification.

[0219] The recall-memory enhancing items, described in this application and stored in the database **700**, can be permanently stored on the user device **2610** to ensure that

the user can have access to the password even when the zero-knowledge database **700** is inaccessible, such as when the user device **2610** is offline. The sharing rules associated with recall-memory enhancing items can have a default value of no sharing with any other users of the system. In one embodiment, the user can override the "no sharing" rule and can choose to share the recall-memory enhancing items with other users of the system.

[0220] FIG. **27** shows a map specifying the geographic location to use in accessing a password modification functionality. In one embodiment, instead of going to the geographic location that enables accessing password notification functionality, the user can specify the geographic location by, for example using a map **2700**. The user can specify the desired location **2710** by, for example, selecting a region **2720**.

[0221] A hardware or software processor enabling the display of the map **2700** can determine whether the selected region **2720** is beyond the predetermined threshold, such as 100 feet, 1000 feet, 1 mile, 5 miles, 10 miles, etc. If the selected region **2720** is beyond the predetermined threshold, the processor can tell the user to select a smaller region. In addition, the zero-knowledge database **700** in FIG. **7** can include user location history. The processor can obtain the user location history, and, based on the location history, the processor can determine whether the user has ever been within the region **2720** and/or how frequently the user has been within the region **2720**. If the user has never been in the region **2720**, the processor can suggest to the user to select a different region, because the user is unlikely to find the region **2720** to be memorable. Similarly, if the user has only passed through the region **2720**, without being stationary within the region **2720** for more than a predetermined amount of time, such as an hour, the processor can suggest to the user to select a different region.

[0222] The user can also specify a location by identifying an establishment such as a particular business or a chain of businesses. For example, the user can specify that the geographic location is a particular Starbucks shop, or any Starbucks shop.

[0223] FIG. **28** shows a step in the process of authenticating a user or enabling password modification capability using a zero-knowledge database. The zero-knowledge database **2800** can contain vast amounts of private information about the user that can be used in authenticating the user. The private information can be known only to the user, or the combination of various data structures containing private information and stored in the zero-knowledge database **2800** can be known only to the user. That private information can be used to aid in authentication of the user in various ways. In addition, the private information can be used to enable setting/resetting the password.

[0224] A processor associated with the zero-knowledge database **2800** can select the private information used to authenticate the user. For example, the processor can automatically select memorable items of private information such as geographic locations, photos, and/or sounds to authenticate the user. The processor can also ask the user which data stored in the zero-knowledge database can be used for authentication and/or enabling password setting/resetting capability. For example, the processor can ask which category of data should be used, such as images, diary entries, songs, etc. In another example, the processor can present the user with specific questions, and the user can choose which questions can be used for authenticating and/or setting/resetting the password.

[0225] In one embodiment, the processor can forgo password authentication and rely on authenticating the user by receiving answers to questions presented to the user. In another embodiment, the processor can grant access to the password by authenticating the user through presenting questions and receiving answers contained in the zero-knowledge database **2800**. In a third embodiment, the processor can enable the user to set/reset the password after the user authenticates himself by providing correct answers to the presented questions.

[0226] In one embodiment, the processor can present recall-memory enhancing items **2810** to the user. The recall-memory enhancing items **2810** can be images. The images **2810** can include various images contained in the user's universal data scaffold. The processor can ask the user to identify the location of each of the images. If the user correctly identifies the location of each of the images, the processor can authenticate the user.

[0227] The zero-knowledge database **2800** can store the user's playlist. To authenticate the user, the processor can ask the user for his favorite song. If the favorite song is contained in the user's playlist, the processor can authenticate the user.

[0228] In another embodiment, the processor can populate the recall-memory enhancing items **2810** with the dummy information not associated with the user. The processor can ask the user to identify the information that is associated with the user. If the user correctly identifies his/her information, the processor can authenticate the user.

[0229] For example, the processor can ask the user which of the presented places shown in images **2810** the user has visited. The processor can include places the user has not visited in the images. If the user selects the correct images, the processor can authenticate the user. In another example, the processor can present a list of recipes, and ask the user to identify which ones the user has made. Similarly, the processor can include recipes that are not associated with the user's universal data scaffold. If the user correctly identifies the recipes, the processor can authenticate the user.

[0230] The zero-knowledge database **2800** can store the type of data structures that can be used to authenticate the user. For example, the types of data structures that can be used to authenticate the user can include photos, geographic locations, songs, recipes, family members, user's diary, etc. In addition, the processor can ask the user to identify the types of data structures that can be used for authentication. The questions presented to the user can vary between different user logins.

[0231] FIG. **29** shows an example implementation of a zero-knowledge personal assistant **2900**. The personal assistant **2900**, also referred to as a "virtual assistant," can perform tasks or offer suggestions using a combination of private data on that resides on the user's device and relationships between data structures defined by a universal data scaffold. The personal assistant can be implemented on a variety of devices beside the mobile device shown in FIG. **29**, such as smart watches, speakers, or VR devices.

[0232] The zero-knowledge personal assistant can be implemented by a rules-based matching system that privately matches user information with content or suggestions that reside in the user's universal data scaffold. For example, the matching system can include rules that match the user's

location with suggestions of local activities. In some implementations, the personal assistant **2900** is implemented as part of the data management platform **110** shown in FIGS. **1** and **13**.

[0233] Users can query the personal assistant **2900** for information or to request a task be performed, such as requesting a weather report, a recipe, or setting a reminder. The personal assistant can then respond using a combination of information from the universal data scaffold, private information on the user's device, and external information, e.g., the internet. For example, if the user asks, "What should I eat for dinner?", the personal assistant can reference a food-related universal data scaffold that defines relationships between multiple data structures. For example, data structures that variously include fields such as user location, user health, time of day can all be correlated to predict what type of food a user may prefer when making the request. The personal assistant can then retrieve a list of recipes or restaurants online. For example, a user whose private structured data indicates the user has an iodine deficiency can be recommended food with higher iodine content, such as seafood. Then if the user is located near a sushi restaurant, then the personal assistant can recommend that restaurant. This can be performed by applying the user's structured data to relationships defined by the universal data scaffold, without additional specific inputs from the user (e.g., additional questions from the virtual assistant).

[0234] In addition, the personal assistant can provide unprompted suggestions such as calendar notifications, reminders, or music recommendations. For example, the personal assistant can suggest the user to get a health screening based on a combination of age and various health indicators, such as a decline in physical activity. In some embodiments, the personal assistant **2900** creates a privately curated feed that includes multiple different content or suggestions and displays that feed on the user device. The unprompted suggestions or reminders can be generated by the personal assistant **2900** based on relationships between structured data defined in the universal data scaffold, similar to responses to queries. In addition, the personal assistant **2900** can use structured user data to determine when or how unprompted suggestions or reminders are presented on a user device. For example, the universal data scaffold can include a location-based rule that presents a notification when a user's device is within a threshold distance of a point of interest. In addition, content and can be recommended based on their personal information, interests, connections, or time of day. Unprompted suggestions can be triggered in response to any changes in the user's data. For example, changes to family, income, purchases, health information can all trigger suggestions. As another example, even the progression of time, as determined by the user's device, is a change in user data that can trigger a suggestion or recommendation.

[0235] In some embodiments, the personal assistant provides unprompted suggestions as additional context to previously made queries or requests, such as updates on a previously searched news story or weather condition. For example, a user who owns a golden retriever dog may get information about that breed. As the dog ages, the personal assistant can share content about aging dogs.

[0236] Furthermore, the virtual assistant retrieves content for the user in a zero-knowledge manner, e.g., using the techniques described in FIG. **11**. The privacy and security provided by these zero-knowledge techniques makes the personal assistant **2900** more suitable for handling sensitive user data compared to existing virtual assistants, which rely on collecting large amounts of user data to make predictions.

[0237] Queries and suggestions can provide a record that is used to improve future answers and suggestions. For example, a user can provide feedback on the quality of suggestions. Alternatively, implicit feedback can be provided, for example based on whether or not a suggestion is selected. The feedback is then used to modify the relationships and rules used by the personal assistant, as derived from the universal data scaffold. In this manner, the personal assistant can learn to predict common user queries and begin to suggest answers preemptively. Furthermore, this process is performed locally on the user's device, ensuring that private information is not shared with other parties. This is more secure compared to existing services that rely on collecting large amounts of user data to train models.

[0238] FIG. **30** shows a form **3000** including input fields **3005** that can be populated using a zero-knowledge database. For example, the form **3000** can be a web form or HTML form, such as a web form for entering payment information, submitting an application, registering an account, etc. The input fields **3005** can include text fields, checkboxes, radio buttons, or other inputs.

[0239] The input fields **3005** can be automatically populated with information defined by a universal data scaffold. In some embodiments, this automatic population can be initiated by a single action on a graphic user interface, such as button displayed on a user device. This can reduce the number of inputs the user device needs to process to complete the form.

[0240] In some embodiments, the form **3000** is filled by a virtual assistant, e.g., the personal assistant **2900**. For example, a user can request the personal assistant **2900** to fill the form **3000** by a voice or text command. In some implementations, the personal assistant **2900** is configured to recognize forms and associated fields according to rules defined in a universal data scaffold, such as by using OCR.

[0241] In some cases, the input fields **3005** can be tagged, similar to HTML. In these cases, a data management platform (e.g., data management platform **110**) can associate the tags with definitions or metadata of a universal data scaffold and then populate the input fields **3005** with information contained in corresponding structured data on the user device. In some embodiments, the form **3000** can be provided by the data management platform or created from a template provided by the platform, and both the requester of the information and the user inputting information in the form can be users of the data management platform. In this case, because the requester and the user have access to the same universal data scaffold, the requester's form can be configured to accept user's structured data with minimal manual input.

[0242] In other cases, an input field may be untagged, or the form may use an unusual format, in which case text recognition or OCR can be performed. This can be more common if the requester providing the form is not a user of the data management platform. The data management platform can analyze the form to identify the types of information being requested. For example, a user may want to fill out a form from with a vehicle inspection service to renew his or her vehicle registration, which generally will require information such as license plate number, VIN, etc. The data

management platform can analyze the form to determine that the form is related to cars and identify a corresponding universal data scaffold, such as car universal scaffold **305** shown in FIG. **3**. The corresponding structured data on the user's device can then automatically be used to fill out the form.

[0243] However, if both a vehicle inspection service and a customer of the service are both users of the data management platform **110**, then the form can be automatically populated without OCR because the form and user's data are both configured based on the universal data scaffold. In either case, compared to searching a conventional database, the structured data scaffolds enable the platform to more efficiently search for and identify relevant information to populate the form.

[0244] If fields are not automatically populated, then the user can enter a manual input. In some embodiments, entering a manual input in a field enables other fields to be automatically filled. For example, manually entering an address can trigger the personal assistant **2900** to automatically fill a zip code.

[0245] In some embodiments, content identified from analyzing the form can be added to the user's universal data scaffold. For example, a vehicle registration form may request the vehicle's current mileage, but the user's universal scaffold may not currently include mileage information. In this example, the user can manually input the value into the form, and an attribute "mileage" can be added to the user's universal data scaffold. This can include adding mileage information to an existing data structure or creating a new data structure with the information.

[0246] Conversely, the universal data scaffold can be used to determine information being requested on a form. For example, the form can include text, but also fields that are untagged. The data management platform can perform OCR on the form to identify text and derive meaning from the text using a universal data scaffold stored on a user's device. This improves privacy for a user compared to relying on an external database or an online search to determine meaning from a string of text. For example, the data management platform can identify the words "make" or "model" from a vehicle registration form and determine that the form is requesting the make or model of a vehicle based on an existing data scaffold structure, such as scaffold **305** in FIG. **3**.

[0247] Once a form is populated, the information can be transferred to the requesting party in a zero-knowledge manner, as described in the present document. For example, the information entered in the form can be encrypted and transferred in bundles. In some embodiments, the requester can obtain information and fill out a form with one click, without input from the requestee. For example, the requestee can have a sharing rule enabled that allows certain data to be transferred to other users of the data management platform. Thus, a requester who is also a user of the data management platform can automatically obtain information to fill out a form. In some instances, the requester can request permission from a user for information, and the form can be automatically filled out if permission is granted, without needing additional input from the user.

[0248] A user who provides information to a requester through the data management platform can set rules that restrict how the information is used. For example, the user may want to provide personal information for purposes of filling out a form, but may not want that information to be sent to other parties or be used for other purposes. Such information can be associated with a rule that prevents the requester from further transferring the data. Other rules can specify a length of time before the information is deleted or before revoking access.

[0249] In addition to filling out structured forms with specified types of information associated with each field, such as form **3000**, the universal data scaffold can be used with unstructured forms. For example, in addition to requesting a patient's "Name" and "Insurance ID," a psychiatrist may ask a patient to fill out a form with open-ended questions in order to generate discussion. The patient can manually fill out a response without associating the information with a specific type, such as "psychiatrist". In some embodiments, a generic tag, such as "information," is applied. The response can then be stored securely in the user's device for future reference. In some embodiments, the data management platform assists the user in filling out unstructured forms by parsing text currently entered in the form and making suggestions or recommendations based on the parsed text and associated information in the user's universal data scaffold. For instance, an online job application can include an open-ended field for the applicant to describe any relevant information not included in his or her resume. As the applicant describes a specific work experience, the description can be supplemented with details such as date or location, filled in from the data from the applicant's device according to relationships defined in the universal data scaffold.

[0250] FIG. **31** shows an example of DNA information that can be stored using the data management platform and structured according to a universal data scaffold. DNA testing can be used to identify and predict potential health issues. Meanwhile, the cost of sequencing DNA has continued to decrease, enabling more people to obtain DNA tests. A large amount of information can be derived from a person's genetic information, including family history and predisposition toward various physical traits. Moreover, a person's DNA, regardless of what can be derived from it, is inherently personal. Therefore, it is crucial that genetic information can be stored and shared in a private and secure manner. In addition to genetic information, similar privacy issues apply to health information in general, including age, weight, drug use, medical history, mental health, etc.

[0251] These issues can be addressed by storing genetic information in a universal data scaffold and transferring genetic data using the zero-knowledge methods described in this document. For example, a user may wish to have their DNA analyzed by a third-party laboratory. The user can verify his or her identity using the zero-knowledge methods described above, after which the third-party lab can transfer the results to the user through the data management platform, for example using the methods described elsewhere in this document. Transferring DNA testing results through the data management platform can increase privacy of the sensitive data and prevent a malicious third-party from accessing the information.

[0252] DNA sequencing data can be stored privately in a user's device. Meanwhile, algorithms or other analytical tools can be stored in the universal data scaffold. As a result, a user does not need to rely on transmitting genetic data elsewhere for analysis, but can instead use the algorithms provided by the data management platform. For example, a

user may want to analyze his or her DNA sequence to determine a likelihood of having high blood pressure. In this case, a suitable algorithm that analyzes a DNA sequence to determine probability of having high blood pressure can be stored in the universal data scaffold, so the user can privately determine results of the analysis. In addition, the universal data scaffold can associate a user's DNA with a wide range of algorithms and tools that generate a variety of predictions and recommendations. For example, these algorithms and tools can analyze a user's DNA to predict risk of diabetes, predict susceptibility to diseases such as COVID-19, generate a recommended diet, or determine ancestry. The universal data scaffold can acquire and store new analytical algorithms as they are developed. The new algorithms can be applied to the DNA sequencing data stored in the universal data scaffold to provide a continually updating DNA analysis for the user. Storing analytical tools in the universal data scaffold reduces latency and bandwidth use by reducing the need to transmit DNA data to separate servers for analysis.

[0253] In some embodiments, it can be preferable to transfer genetic data to a third party, such as for analysis. For example, greater computing power may be needed than is available on a user's device, or certain proprietary analytical methods may be unavailable in the universal data scaffold, e.g., due to lack of permission. Therefore, methods of transmitting the DNA data anonymously are sometimes needed. In some embodiments, a user can send a sample (e.g., a saliva sample) for sequencing to a third party, who then transmits the raw sequence data anonymously to another party for data analysis. In some implementations, the raw sequence data can be transmitted through the data management platform such that the analyzing party does not associate the sequence with the user.

[0254] Although such methods provide improved privacy compared to existing DNA analysis services, DNA by its nature inherently contains information about the user. Thus, when genetic data needs to be transferred for analysis, the anonymization of genetic data can be further be improved by homomorphic encryption. Homomorphic encryption enables operations to be performed directly on the encrypted data without first decrypting it. After computations are performed on the encrypted data, the results can then be decrypted by the user using his or her private key. The decrypted results are identical to the results produced if the same computations were performed on decrypted data. However, using homomorphic encryption ensures that any analysis of DNA data remains encrypted until it is decrypted by the user. A variety of homomorphic encryption methods can be used, such as encryption can be based on the Ring Learning With Errors (RLWE) problem. In some embodiments, homomorphic encryption can be implemented using existing libraries, such as Microsoft® SEAL, PALISADE, etc. In some embodiments, the homomorphically encrypted data can be transmitted between multiple third-parties for analysis, all without needing to decrypt the data until the user receives the results.

[0255] In some embodiments, a doctor can use the data management platform to aid in diagnosis. For example, DNA analysis can indicate whether a patient is prone to certain diseases. A patient can privately share encrypted DNA or DNA analysis results with the doctor through the data management platform, without sharing genetic information with third-party services. In some implementations, this information can shared while automatically filling out medical forms prior to an appointment.

[0256] A virtual assistant, such as the personal assistant **2900**, can use health information to make recommendations, display reminders, converse with the user, and perform other health-related tasks. For example, the virtual assistant can recommend health screening exams based on a user's personal information. In another example, the virtual assistant can recommend healthy recipes based on time of day. As previously described, health data is privately stored on the user device, and relationships and rules defined by the universal data scaffold are used to analyze the health data, also on the user device. As a result, sensitive health information remains secure, including age, weight, drug use, medical history, dental records, etc.

[0257] In some embodiments, the personal assistant **2900** can track a user's mental health. For example, the personal assistant **2900** can periodically request a status update regarding status or mood. The user's response can include words or a numerical sentiment score (e.g., from 1 to 10). In some embodiments, the personal assistant **2900** can perform natural language processing of response text and perform sentiment analysis, for example using a sentiment analysis model included in the universal data scaffold, to determine the user's emotion or mental state. The sentiment can be tracked over time.

[0258] Based on the sentiment tracking, the personal assistant **2900** can then recommend content, send reminders, or converse with the user. For example, a user may give responses that indicate low happiness over a given time period. The rules defined by the universal data scaffold can associate low happiness and time with depression. In response, the personal assistant **2900** can recommend feel-good news stories, offer encouraging reminders, or converse with the user (e.g., using a chat interface with an AI chatbot function.) In some embodiments, the personal assistant **2900** combines the sentiment data with the genetic data described above. For example, a user's DNA can indicate a genetic predisposition to depression, alcoholism, etc., which can affect the recommendations made by the personal assistant **2900**. Thus, combining sentiment data with genetic data can improve the relevance of the personal assistant **2900**'s recommendations.

[0259] FIG. **32** shows an example of location-sharing using a zero-knowledge database. Although existing systems allow users to voluntarily share location information with other users, there are situations where explicit permission is less feasible. For example, parents may want to monitor their children's after-school locations in real time, while their children may not want to share this information. Thus, in some embodiments, the data management platform can enable secure sharing of location between users based on a type of relationship between the users, without explicit permission from at least one of the parties. The data management platform can first derive the type of relationship between two parties based on content associated with each user's universal data scaffold, and then either allow or disallow location sharing accordingly. For example, the users can store family information in the platform such that the relationship is directly determined. In another example, the relationship can be determined less directly, for example by analyzing images or communications between the two

users. In addition, sharing can be automatically enabled in this manner for other types of content, not only location information.

[0260] FIG. **33** shows an example of a security notification **3300**. The security notification **3300** can be displayed by the personal assistant **2900** of FIG. **29**. The universal data scaffold structure can be used to provide an improved process for enabling automatic notifications of compromised information. For example, if a spouse's account is compromised, and the spouse shares passwords with their partner through the data management platform, the partner can be securely alerted of which shared passwords were compromised. Because the platform uses a zero-knowledge manner of transmitting information, these alerts can be transmitted without identifying which accounts were hacked. In comparison, current systems, such as those used by financial institutions, can alert a customer if an account has been breached or there is suspicious activity associated with the account. However, these systems generally transmit account information to the customer, e.g., the last 4 digits of the account, which can expose these accounts to malicious actors.

[0261] FIG. **34** shows a user operating a virtual reality (VR) device that can display representations of content defined using a universal data scaffold. In addition to accessing digital content though a user interface on a device such as a phone, as shown in FIG. **7**C, a user can view, modify, or create digital content in the VR space. For example, a VR device can include a head-mounted display, speakers, controllers, etc. Digital content stored in the data management platform can further be accessed through any suitable hardware in various forms. For example, digital content can be viewed as augmented reality (AR) content or streamed as audio-only.

[0262] The VR space can use the universal data scaffold associated with specific digital content to show various attributes associated with the digital content and/or any related digital contents. Thus, some digital content can be selected by the user, while other content can be automatically selected by the data management platform based on associations derived from the universal data scaffolding. For example, a user may store overseas vacation photos on the data management platform, which can be displayed in the VR space. These photos can then be automatically supplemented by passport information, audio recorded during the trip, etc. Using another vehicle example, a user's vehicle can be viewed in VR in a virtual garage and supplemented with additional attributes, such as accurate license plate information and details specific to the specific year's make and model.

[0263] In some embodiments, the private VR space can be a part of a larger metaverse. As described above, users of the data management platform can share content with each other according to various sharing rules. Shared content from other users can then be accessed by entering other user's VR spaces. Furthermore, a community space can include representations of shared content from multiple users.

[0264] A VR space can be selectively shared so that some aspects of the space remain private while other aspects are shared. The sharing of objects within the VR space can be guided by sharing rules stored within the universal data scaffold. The sharing rules can be associated with the VR space, the owner of the VR space, or visitors to the VR space. Furthermore actions, dialogue, or other interactions within a user's private VR space can be governed by the universal data scaffold. For example, some conversations can be private between users even if other users are within hearing distance in the VR space. In another example, different users may hear different dialogue or see different objects within the same VR space. The universal data scaffold enables broad connections of information represented in the VR space, while privacy is maintained by delivering the information in a zero-knowledge manner.

[0265] For example, table **3402** in FIG. **34** is private to the user, so that the table **3402** is not visible to other users who enter the VR space. Meanwhile, other objects, such as the duck **3404**, are visible to all users. In general, a VR space or the objects within the space can be governed by a set of rules that define access restrictions for different users in the space. In some embodiments, certain user avatars are invisible to other users, allowing these invisible users to "eavesdrop" on the VR space. For example, selectively enabling which avatars are visible in the VR environment can reduce distractions during meetings or negotiations for the visible parties while invisible users listen and observe.

[0266] A user in the metaverse can be associated with portable identity information. For example, this portable identity information can include real world information, such as name, birthday, etc. The portable identity can also include metaverse-specific information, such as an avatar ID and avatar appearance. Other types of metaverse-specific information include data derived from user equipment, such as eye-tracking data from sensors in head mounted displays or movement information from controllers. This information can be stored in the data management platform using the universal data scaffolding structure described above, so that the information is secure for the user. A user can then share or transfer portable identity information as needed to access services in the metaverse, for example to enter a venue that is restricted by age. This can be similar to providing information through a web form, as described in relation to FIG. **30** above, except implemented in a VR environment.

[0267] FIG. **35** is a flow diagram of a method **3500** of implementing a logging system using a universal data scaffold. Organizations that handle customer or user data often aim to meet certain compliance standards, such as the American Institute of CPAs' System and Organization Control 2 (SOC2) or the Payment Card Industry Data Security Standard (PCI DSS). Many of these standards include requirements for logging of access and modification to sensitive data in order to provide opportunities to identify and respond to behavior that is indicative of a security breach. The universal data scaffold can be used to implement a highly detailed and customizable enterprise logging system as follows.

[0268] At **3505**, access logs and data modifications associated with an organization are recorded. The data can include user identifiers, timestamps, the state of the data prior to modification, a list of actions or changes taken, etc. In some embodiments, a system administrator of the organization can select which data to include in the access logs. Optionally, the logging system can be integrated with an external monitoring tool. At **3510**, suspicious activity is detected, and an alert is sent to the system administrator. At **3515**, log data is stored. Organizations that rely on third-party logging management potentially risk exposing sensitive information, while privately storing log data ensures that log data remain secure within the organization.

[0269] FIG. **36** is a flow diagram illustrating a method **3600** of implementing a zero-knowledge personal assistant. At **3602**, a user device downloads a universal data scaffold. For example, the universal data scaffold can be similar to those depicted in FIGS. **1-3**. At **3604**, the user device obtains user data associated with a user of the user device. At **3606**, the user device stores the user data in a data structure defined by the universal data scaffold from step **3602**, where the data structure is configured to represent the user's information. For example the data structure can be similar to the data structures shown in FIGS. **7**A, **8**, and **21**. The data structure defines a relationship between a plurality of attributes included in the data structure. Furthermore, the data structure is associated with a set of rules that, when applied to values of the plurality of attributes as inputs, outputs a prediction associated with the user data.

[0270] At **3608**, the user device applies the set of rules associated with the data structure to the user data. In some embodiments, **3608** is performed in response to a request by the user, e.g., to a virtual assistant executing on the user device. In some embodiments, the rules are applied without prompting from the user. At **3610**, a virtual assistant (e.g., virtual assistant **2900**), based on applying the set of rules to the user data, determines a recommendation based on the prediction associated with the user data. At **3612**, the virtual assistant presents the recommendation determined at **3610** on the user device.

[0271] In some embodiments, the clauses below can be used to implement a zero-knowledge virtual assistant:

[0272] Clause 1. A computer-implemented method of implementing a virtual assistant on a user device, the method comprising: downloading, by the user device, a universal data scaffold; obtaining, by the user device, user data associated with a user of the user device; storing, by the user device, the user data in a data structure defined by the universal data scaffold, the data structure configured to represent the user's information, wherein the data structure defines a relationship between a plurality of attributes included in the data structure, and wherein the data structure is associated with a set of rules that, when applied to values of the plurality of attributes as inputs, outputs a prediction associated with the user data; applying the set of rules associated with the data structure to the user data; and based on applying the set of rules to the user data, determining a recommendation based on the prediction associated with the user data; and presenting, by the virtual assistant, the recommendation on the user device.

[0273] Clause 2. The computer-implemented method of clause 1, wherein the user data includes health information and location information, and wherein the recommendation is determined based on the health information and the location information.

[0274] Clause 3. The computer-implemented method of clause 1 or 2, wherein the recommendation is presented on the user device without receiving a request for information from the user.

[0275] Clause 4. The computer-implemented method of any of clauses 1-3, wherein the data structure includes a hierarchical graph including a plurality of nodes, the plurality of nodes representing the plurality of attributes.

[0276] Clause 5. The computer-implemented method of any of clauses 1-4, wherein the set of rules is a first set of rules, and wherein the data structure is associated with a second set of rules that defines, based on the plurality of attributes, a usage restriction of the user data.

[0277] Clause 6. The computer-implemented method of any of clauses 1-5, further comprising: performing zero-knowledge encryption on at least a portion of the user data; transmitting, over a network to a third-party server, a request for information associated with the recommendation, the request including the portion of the user data; and in response to transmitting the request, receiving, from the third-party server, the information associated with the recommendation, wherein presenting the recommendation includes presenting the information received from the third-party server.

[0278] Clause 7. The computer-implemented method of any of clauses 1-6, further comprising: displaying, on the user device, a form including a plurality of fields; mapping the user data to the plurality of attributes included in the data structure; mapping the plurality of attributes to the plurality of fields; and automatically entering, by the virtual assistant, the user data into the plurality of fields.

[0279] Clause 8. The computer-implemented method of clause 7, further comprising: receiving, by the user device from the user, an input including an entry into a field of the plurality of fields; and updating, based on the set of rules, the user data entered in the plurality of fields.

[0280] Clause 9. The computer-implemented method of any of clauses 1-8, wherein the user data includes genetic data, and wherein downloading the universal data scaffold includes downloading a genetic analysis algorithm, the method further comprising: analyzing, by the user device, the genetic data using the genetic analysis algorithm to derive a health trait of the user, wherein the recommendation is based on the derived health trait.

[0281] Clause 10. The computer-implemented method of any of clauses 1-9, further comprising: receiving, by the user device, a message via user-input; and detecting, by the virtual assistant, an emotion or mental state associated with the message by applying a sentiment analysis model to the message, wherein the recommendation includes a mental health recommendation based on the emotion or mental state.

[0282] Clause 11. The computer-implemented method of any of clauses 1-10, wherein the user device is a VR device, wherein applying the set of rules causes an appearance of a VR object in a VR space to differ among users in the VR space.

[0283] Clause 12. The computer-implemented method of any of clauses 1-11, wherein the user device is a VR device, wherein applying the set of rules causes a first VR object to be visible to both a first user and a second user, and wherein applying the set of rules causes a second VR object to be visible to the first user and invisible to the second user.

[0284] Clause 13. The computer-implemented method of any of clauses 1-12, wherein the recommendation includes a security notification.

[0285] Clause 14. A computer-implemented method of implementing a virtual assistant on a user device, the method comprising: downloading, by the user device, a universal data scaffold, the universal data scaffold including a genetic analysis algorithm; obtaining, by the user device, genetic data associated with a user of the user device; storing, by the user device, the user data in a data structure defined by the universal data scaffold, the data structure configured to represent the user data, wherein the data structure defines a

relationship between a plurality of attributes included in the data structure, and wherein the data structure is associated with a set of rules that, when applied to values of the plurality of attributes as inputs, outputs a prediction associated with the user data; applying, by the user device, the set of rules associated with the data structure to the genetic data, including: analyzing, by the user device, the genetic data using the genetic analysis algorithm to predict a health trait of the user; based on applying the set of rules to the genetic data, determining a recommendation based on the predicted health trait; and presenting, by the virtual assistant, the recommendation on the user device.

[0286] Clause 15. A computer-implemented method comprising: downloading a universal data scaffold to a computing device; receiving, by a virtual assistant executing on the computing device, a message via user-input to the computing device; detecting, by the virtual assistant, an emotion or mental state of the user by applying a sentiment analysis model to the message; storing user data indicative of the emotion or the mental state in a data structure defined by the universal data scaffold, the data structure configured to represent the user data, wherein the data structure defines a relationship between a plurality of attributes included in the data structure, and wherein the data structure is associated with a set of rules that, when applied to values of the plurality of attributes as inputs, outputs a prediction associated with the user data; applying the set of rules associated with the data structure to the user data; based on applying the set of rules to the user data, determining a recommendation based on the prediction associated with the user data; and presenting, by a virtual assistant executing in the computing device, the recommendation to the user.

[0287] Clause 16. A computer-readable storage medium, excluding transitory signals and carrying instructions, which, when executed by at least one data processor of a system, cause the system to perform any of the methods of clauses 1-15.

[0288] Clause 17. A computing device including a processor and a memory storing instructions, which, when executed by the processor, cause the computing device to perform any of the methods of clauses 1-15.

Computer

[0289] FIG. **37** is a block diagram of a computer system as may be used to implement features of some embodiments of the disclosed technology. The computing system **3700** may be used to implement any of the entities, components or services depicted in the foregoing figures (and any other components described in this specification). The computing system **3700** may include one or more central processing units ("processors") **3705**, memory **3710**, input/output devices **3725** (e.g., keyboard and pointing devices, display devices), storage devices **3720** (e.g., disk drives), and network adapters **3730** (e.g., network interfaces) that are connected to an interconnect **3715**. The interconnect **3715** is illustrated as an abstraction that represents any one or more separate physical buses, point to point connections, or both connected by appropriate bridges, adapters, or controllers. The interconnect **3715**, therefore, may include, for example, a system bus, a Peripheral Component Interconnect (PCI) bus or PCI-Express bus, a HyperTransport or industry standard architecture (ISA) bus, a small computer system interface (SCSI) bus, a universal serial bus (USB), IIC (I2C) bus, or an Institute of Electrical and Electronics Engineers (IEEE) standard 1394 bus, also called "Firewire".

[0290] The computing system **3700** can be associated with the user device **2305** in FIG. **23** and/or associated with the server **2300** in FIG. **23**. The computing system **3700** can execute instructions as described in this application, for example, FIGS. **24-28**. The network adapter **3730** can facilitate communication between the user device **2305** and the server **2300**.

[0291] The memory **3710** and storage devices **3720** are computer-readable storage media that may store instructions that implement at least portions of the described technology. In addition, the data structures and message structures may be stored or transmitted via a data transmission medium, such as a signal on a communications link. Various communications links may be used, such as the Internet, a local area network, a wide area network, or a point-to-point dial-up connection. Thus, computer-readable media can include computer-readable storage media (e.g., "non-transitory" media) and computer-readable transmission media.

[0292] The instructions stored in memory **3710** can be implemented as software and/or firmware to program the processor(s) **3705** to carry out actions described above. In some embodiments, such software or firmware may be initially provided to the computing system **3700** by downloading it from a remote system through the computing system **3700** (e.g., via network adapter **3730**).

[0293] The technology introduced herein can be implemented by, for example, programmable circuitry (e.g., one or more microprocessors) programmed with software and/or firmware, or entirely in special-purpose hardwired (non-programmable) circuitry, or in a combination of such forms. Special-purpose hardwired circuitry may be in the form of, for example, one or more ASICs, PLDs, FPGAs, etc.

[0294] Although the invention is described herein with reference to the preferred embodiment, one skilled in the art will readily appreciate that other applications may be substituted for those set forth herein without departing from the spirit and scope of the present invention. Accordingly, the invention should only be limited by the Claims included below.

Remarks

[0295] The above description and drawings are illustrative and are not to be construed as limiting. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in some instances, well-known details are not described in order to avoid obscuring the description. Further, various modifications may be made without deviating from the scope of the embodiments. Accordingly, the embodiments are not limited except as by the appended claims.

[0296] Reference in this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by

others. Similarly, various requirements are described which may be requirements for some embodiments but not for other embodiments.

[0297] The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Terms that are used to describe the disclosure are discussed below, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, some terms may be highlighted, for example using italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that the same thing can be said in more than one way. One will recognize that "memory" is one form of a "storage" and that the terms may on occasion be used interchangeably.

[0298] Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for some terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any term discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

[0299] Those skilled in the art will appreciate that the logic illustrated in each of the flow diagrams discussed above, may be altered in various ways. For example, the order of the logic may be rearranged, substeps may be performed in parallel, illustrated logic may be omitted; other logic may be included, etc.

[0300] Without intent to further limit the scope of the disclosure, examples of instruments, apparatus, methods, and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

1. A computer-implemented method of implementing a virtual assistant on a user device, the method comprising:

applying a set of rules defined by a universal data scaffold to user data associated with a user of the user device to generate a recommendation based on a prediction produced by the application of the set of rules;

presenting, by the virtual assistant, the recommendation on the user device by:

displaying, on the user device, a form including a plurality of fields;

mapping the user data to a plurality of attributes included in the universal data scaffold;

mapping the plurality of attributes to the plurality of fields; and

automatically entering, by the virtual assistant, the user data into the plurality of fields.

2. The computer-implemented method of claim **1**, wherein the user data further includes location information, and wherein the recommendation is determined based on the location information.

3. The computer-implemented method of claim **1**, wherein the recommendation is presented on the user device without receiving a request for information from the user.

4. The computer-implemented method of claim **1**, wherein the universal data scaffold includes a hierarchical graph including a plurality of nodes, the plurality of nodes representing the plurality of attributes.

5. The computer-implemented method of claim **1**, wherein the set of rules is a first set of rules, and wherein the universal data scaffold is associated with a second set of rules that defines, based on the plurality of attributes, a usage restriction of the user data.

6. The computer-implemented method of claim **1**, further comprising:

performing zero-knowledge encryption on at least a portion of the user data;

transmitting, over a network to a third-party server, a request for information associated with the recommendation, the request including the portion of the user data; and

in response to transmitting the request, receiving, from the third-party server, the information associated with the recommendation,

wherein presenting the recommendation includes presenting the information received from the third-party server.

7. The computer-implemented method of claim **1**, further comprising:

receiving, by the user device from the user, an input including an entry into a field of the plurality of fields; and

updating, based on the set of rules, the user data entered in the plurality of fields.

8. The computer-implemented method of claim **1**, further comprising:

receiving, by the user device, a message via user-input; and

detecting, by the virtual assistant, an emotion or mental state associated with the message by applying a sentiment analysis model to the message,

wherein the recommendation includes a mental health recommendation based on the emotion or the mental state.

9. A computer-readable storage medium, excluding transitory signals and carrying instructions, which, when executed by at least one data processor of a system, cause the system to:

apply a set of rules defined by a universal data scaffold to user data associated with a user of a user device to generate a recommendation based on a prediction produced by the application of the set of rules;

present, by a virtual assistant, the recommendation on the user device by:

displaying, on the user device, a form including a plurality of fields;

mapping the user data to a plurality of attributes included in the universal data scaffold;

mapping the plurality of attributes to the plurality of fields; and

automatically entering, by the virtual assistant, the user data into the plurality of fields.

10. The computer-readable storage medium of claim **9**, wherein the user data includes health information and location information, and wherein the recommendation is determined based on the health information and the location information.

11. The computer-readable storage medium of claim **9**, wherein the recommendation is presented without receiving a request for information from the user.

12. The computer-readable storage medium of claim **9**, wherein the universal data scaffold includes a hierarchical graph including a plurality of nodes, the plurality of nodes representing the plurality of attributes.

13. The computer-readable storage medium of claim **9**, wherein the set of rules is a first set of rules, and wherein the universal data scaffold is associated with a second set of rules that defines, based on the plurality of attributes, a usage restriction of the user data.

14. The computer-readable storage medium of claim **9**, the system further caused to:

perform zero-knowledge encryption on at least a portion of the user data;

transmit, over a network to a third-party server, a request for information associated with the recommendation, the request including the encrypted portion of the user data; and

in response to transmitting the request, receive, from the third-party server, the information associated with the recommendation,

wherein presenting the recommendation includes presenting the information received from the third-party server.

15. The computer-readable storage medium of claim **9**, wherein the user data includes genetic data, and wherein downloading the universal data scaffold includes downloading a genetic analysis algorithm, the system further caused to:

analyze the genetic data using the genetic analysis algorithm to derive a health trait of the user,

wherein the recommendation is based on the derived health trait.

16. The computer-readable storage medium of claim **9**, the system further caused to:

receive a message via user-input; and

detect, by the virtual assistant, an emotion or mental state associated with the message by applying a sentiment analysis model to the message,

wherein the recommendation includes a mental health recommendation based on the emotion or the mental state.

17. A system comprising a hardware processor and a non-transitory computer-readable storage medium storing instructions that, when executed by the hardware processor, cause the hardware processor to perform steps comprising:

applying a set of rules defined by a universal data scaffold to user data associated with a user of a user device to generate a recommendation based on a prediction produced by the application of the set of rules;

presenting, by a virtual assistant, the recommendation on the user device by:

displaying, on the user device, a form including a plurality of fields;

mapping the user data to a plurality of attributes included in the universal data scaffold;

mapping the plurality of attributes to the plurality of fields; and

automatically entering, by the virtual assistant, the user data into the plurality of fields.

18. The system of claim **17**, wherein the user data further includes location information, and wherein the recommendation is determined based on the location information.

19. The system of claim **17**, wherein the recommendation is presented on the user device without receiving a request for information from the user.

20. The system of claim **17**, wherein the universal data scaffold includes a hierarchical graph including a plurality of nodes, the plurality of nodes representing the plurality of attributes.

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