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Ithal et al.

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(45) **Date of Patent: *Aug. 12, 2025**

(54) **DATA POSTURE ANALYSIS IN A CLOUD ENVIRONMENT USING DATABASE SNAPSHOTS**

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(73) Assignee: **Normalyze, Inc.**, Los Altos, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 136 days.

This patent is subject to a terminal disclaimer.

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(Continued)

(51) **Int. Cl.**

H04L 9/40 (2022.01)
G06F 9/451 (2018.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04L 63/1416*** (2013.01); ***G06F 9/451*** (2018.02); ***G06F 16/211*** (2019.01);

(Continued)

(58) **Field of Classification Search**

CPC . H04L 63/1416; H04L 63/083; H04L 63/102; H04L 63/104; H04L 63/1433;

(Continued)

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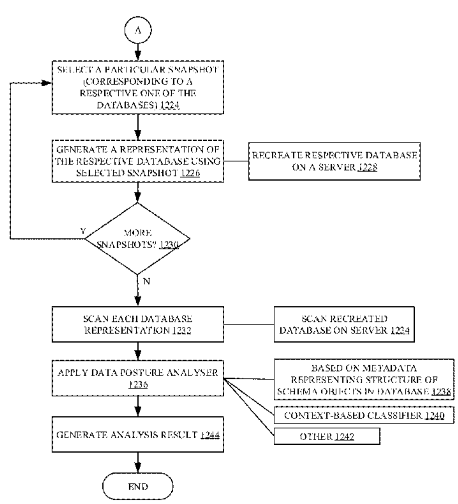
Primary Examiner — Jahangir Kabir

(74) *Attorney, Agent, or Firm* — Flagship Patents; Sikander M. Khan; Chris Volkmann

(57) **ABSTRACT**

The technology disclosed relates to streamlined analysis of security posture of a cloud environment. In particular, the disclosed technology relates to a system that analyzes data posture in a cloud environment database using a snapshot of the database. A computer-implemented method includes receiving a request to access a database in the cloud environment, wherein the database includes a first authentication requirement. The method includes identifying a snapshot of the database, wherein the snapshot includes a second authentication requirement that is different than the first authentication requirement. The method includes accessing the snapshot using the second authentication requirement, generating a representation of the database using the snapshot, and generating a data posture analysis result indicative of a data posture of the database based on scanning the representation of the database.

20 Claims, 33 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 63/246,313, filed on Sep. 21, 2021, provisional application No. 63/246,310, filed on Sep. 21, 2021, provisional application No. 63/246,315, filed on Sep. 21, 2021, provisional application No. 63/246,303, filed on Sep. 20, 2021.

(51) **Int. Cl.**

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G06F 16/245	(2019.01)
G06F 16/355	(2025.01)
G06F 16/95	(2019.01)
G06F 21/57	(2013.01)
G06F 21/62	(2013.01)

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CPC ***G06F 16/24569*** (2019.01); ***G06F 16/355*** (2019.01); ***G06F 16/95*** (2019.01); ***G06F 21/577*** (2013.01); ***G06F 21/6227*** (2013.01); ***H04L 63/083*** (2013.01); ***H04L 63/102*** (2013.01); ***H04L 63/104*** (2013.01); ***H04L 63/1433*** (2013.01); ***H04L 63/18*** (2013.01); ***H04L 63/205*** (2013.01); *G06F 2221/034* (2013.01); *G06F 2221/2141* (2013.01)

(58) **Field of Classification Search**
CPC H04L 63/18; H04L 63/205; G06F 9/451; G06F 16/211; G06F 16/24569; G06F 16/355; G06F 16/95; G06F 21/577; G06F 21/6227; G06F 2221/034; G06F 2221/2141
USPC 726/7
See application file for complete search history.

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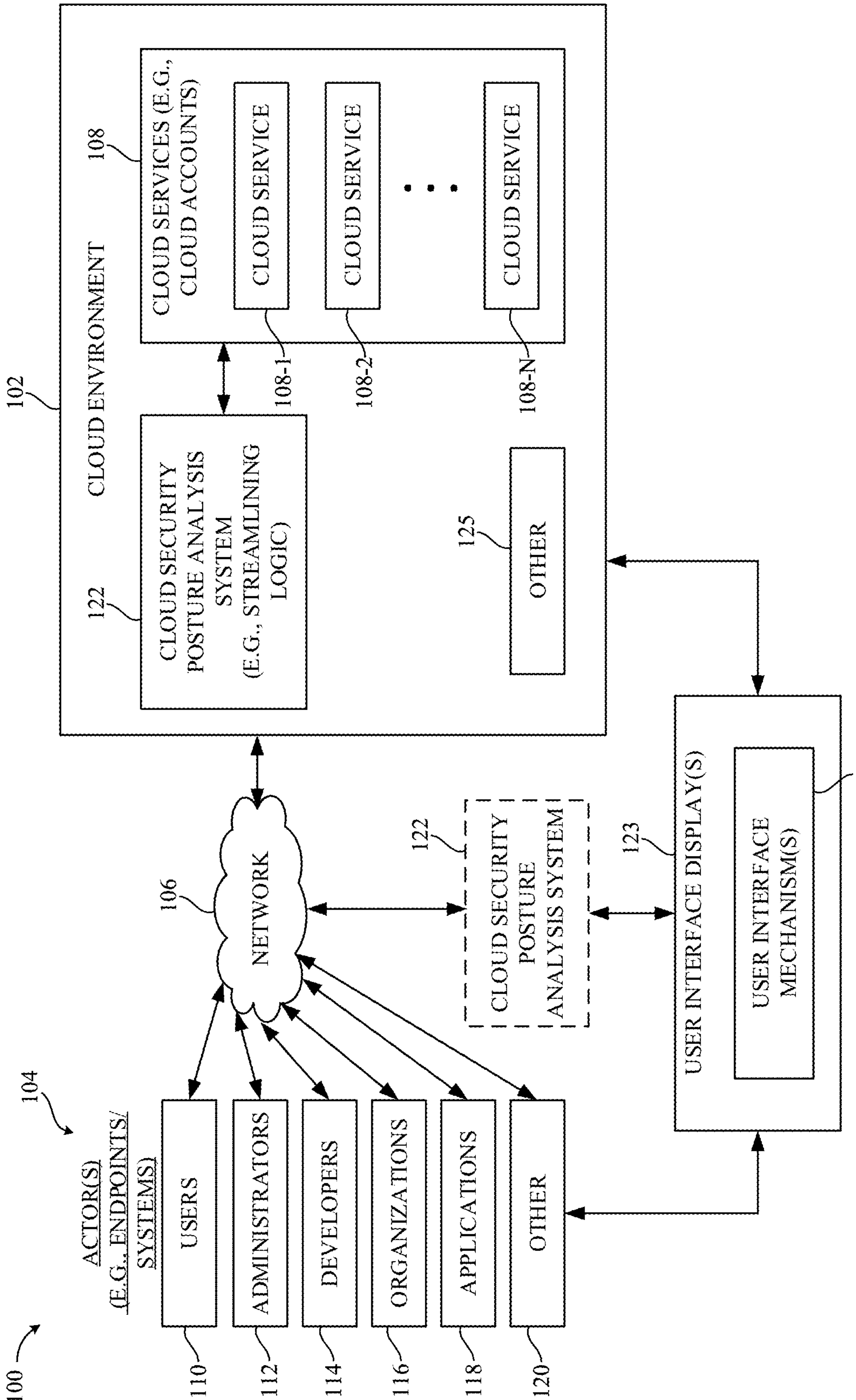

100
104
ACTOR(S)
(E.G., ENDPOINTS/
SYSTEMS)
USERS
ADMINISTRATORS
DEVELOPERS
ORGANIZATIONS
APPLICATIONS
OTHER
110
112
114
116
118
120
106
NETWORK
122
CLOUD SECURITY
POSTURE
ANALYSIS SYSTEM
123
USER INTERFACE DISPLAY(S)
USER INTERFACE
MECHANISM(S)
124
102
CLOUD ENVIRONMENT
122
CLOUD SECURITY
POSTURE ANALYSIS
SYSTEM
(E.G., STREAMLINING
LOGIC)
108
CLOUD SERVICES (E.G.,
CLOUD ACCOUNTS)
CLOUD SERVICE
CLOUD SERVICE
CLOUD SERVICE
108-1
108-2
108-N
125
OTHER

FIG. 1

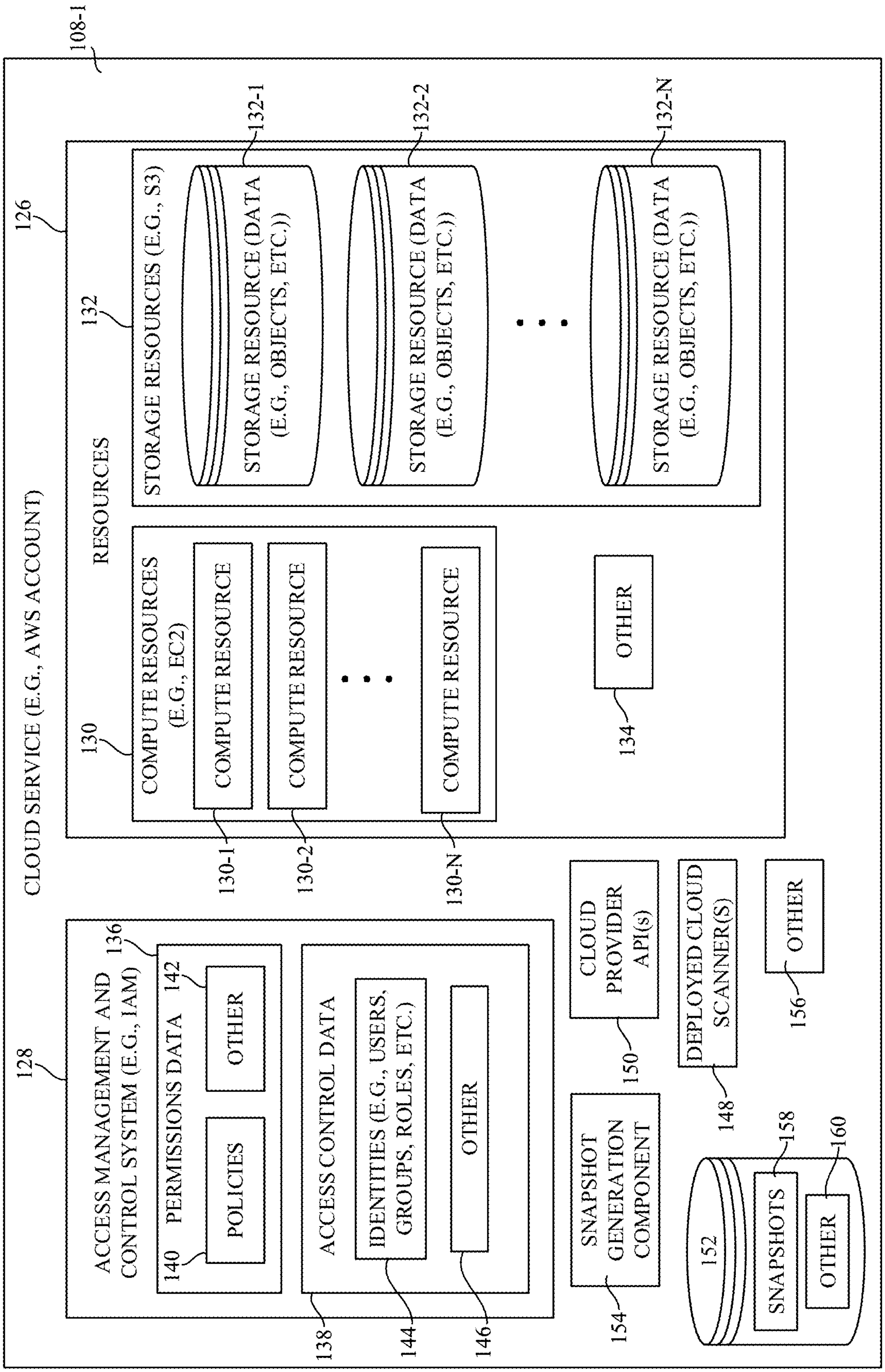

108-1
CLOUD SERVICE (E.G., AWS ACCOUNT)
126
RESOURCES
132
STORAGE RESOURCES (E.G., S3)
132-1
STORAGE RESOURCE (DATA (E.G., OBJECTS, ETC.))
132-2
STORAGE RESOURCE (DATA (E.G., OBJECTS, ETC.))
132-N
STORAGE RESOURCE (DATA (E.G., OBJECTS, ETC.))
130
COMPUTE RESOURCES (E.G., EC2)
COMPUTE RESOURCE
COMPUTE RESOURCE
COMPUTE RESOURCE
130-1
130-2
130-N
OTHER
134
128
ACCESS MANAGEMENT AND CONTROL SYSTEM (E.G., IAM)
136
PERMISSIONS DATA
140
POLICIES
142
OTHER
ACCESS CONTROL DATA
IDENTITIES (E.G., USERS, GROUPS, ROLES, ETC.)
OTHER
138
144
146
CLOUD PROVIDER API(s)
150
DEPLOYED CLOUD SCANNER(S)
148
OTHER
156
SNAPSHOT GENERATION COMPONENT
154
152
SNAPSHOTS
158
OTHER
160

FIG. 2

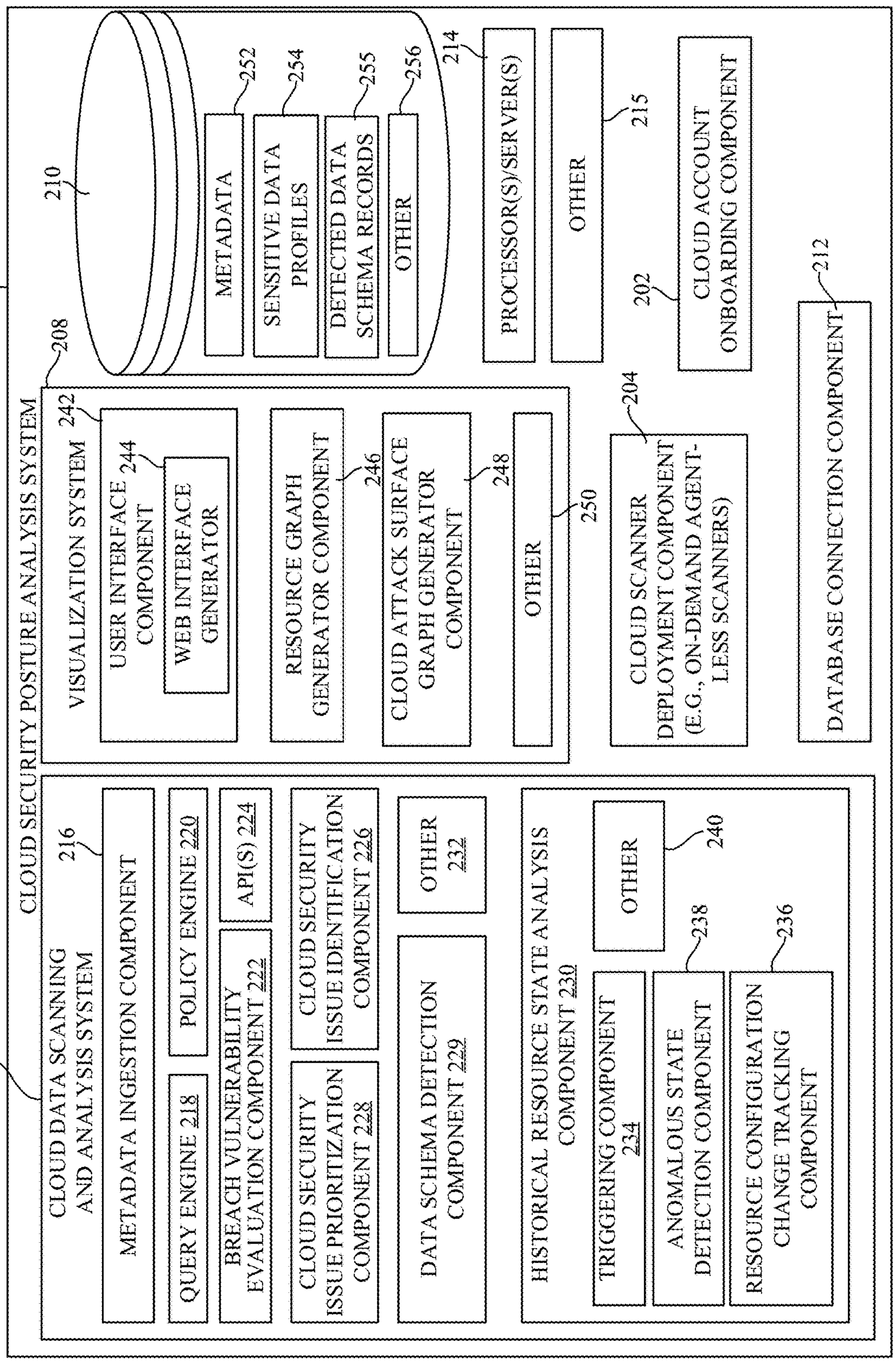

122
CLOUD SECURITY POSTURE ANALYSIS SYSTEM
206
CLOUD DATA SCANNING AND ANALYSIS SYSTEM
216
METADATA INGESTION COMPONENT
QUERY ENGINE 218
POLICY ENGINE 220
BREACH VULNERABILITY EVALUATION COMPONENT 222
API(S) 224
CLOUD SECURITY ISSUE PRIORITIZATION COMPONENT 228
CLOUD SECURITY ISSUE IDENTIFICATION COMPONENT 226
DATA SCHEMA DETECTION COMPONENT 229
OTHER 232
HISTORICAL RESOURCE STATE ANALYSIS COMPONENT 230
TRIGGERING COMPONENT 234
OTHER
240
ANOMALOUS STATE DETECTION COMPONENT
238
RESOURCE CONFIGURATION CHANGE TRACKING COMPONENT
236
208
VISUALIZATION SYSTEM
242
USER INTERFACE COMPONENT
244
WEB INTERFACE GENERATOR
RESOURCE GRAPH GENERATOR COMPONENT
246
CLOUD ATTACK SURFACE GRAPH GENERATOR COMPONENT
248
OTHER
250
204
CLOUD SCANNER DEPLOYMENT COMPONENT (E.G., ON-DEMAND AGENT-LESS SCANNERS)
DATABASE CONNECTION COMPONENT
212
210
METADATA
252
SENSITIVE DATA PROFILES
254
DETECTED DATA SCHEMA RECORDS
255
OTHER
256
214
PROCESSOR(S)/SERVER(S)
OTHER
215
202
CLOUD ACCOUNT ONBOARDING COMPONENT

FIG. 3

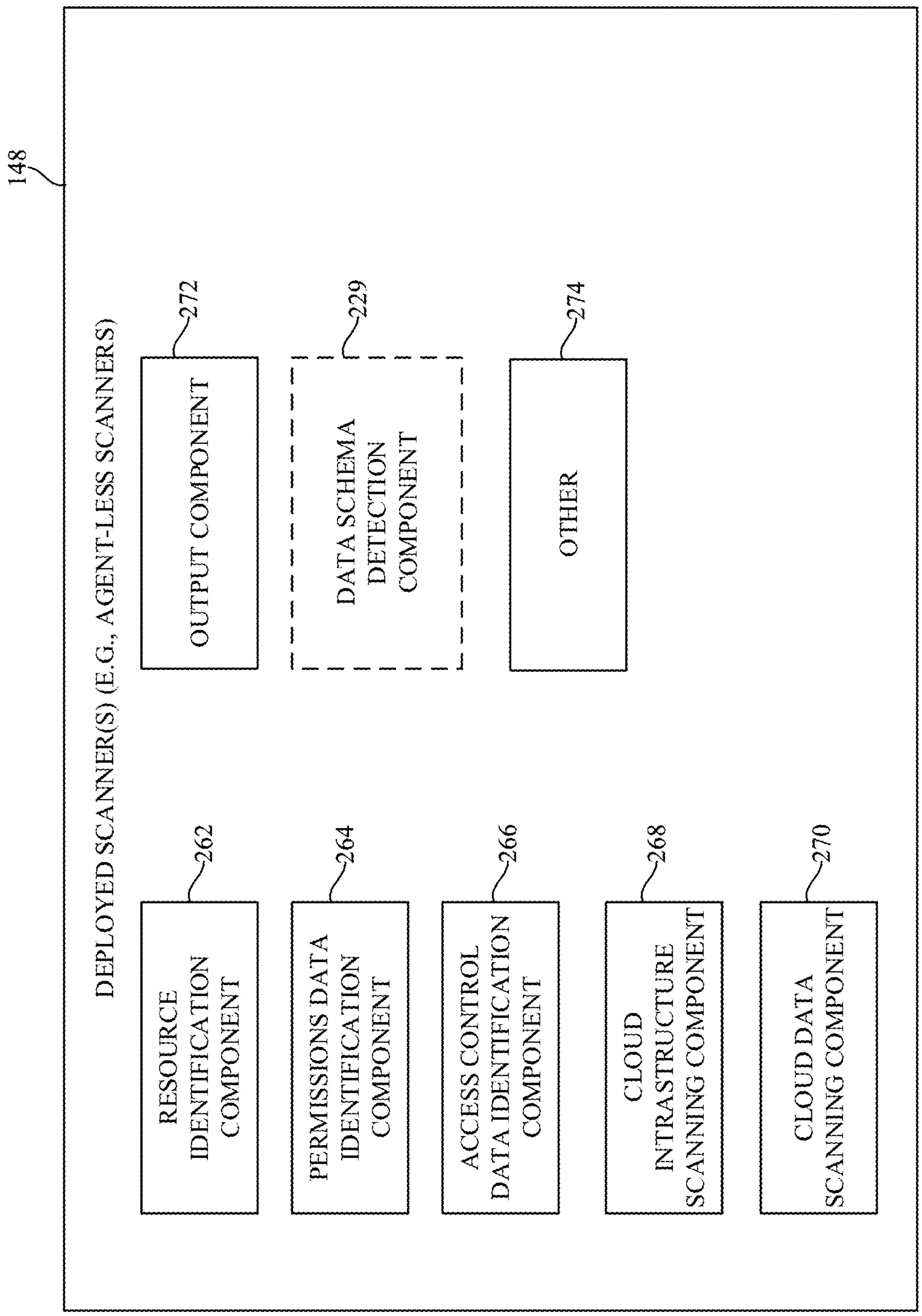

148
DEPLOYED SCANNER(S) (E.G., AGENT-LESS SCANNERS)
RESOURCE IDENTIFICATION COMPONENT
262
PERMISSIONS DATA IDENTIFICATION COMPONENT
264
ACCESS CONTROL DATA IDENTIFICATION COMPONENT
266
CLOUD INTRASTRUCTURE SCANNING COMPONENT
268
CLOUD DATA SCANNING COMPONENT
270
OUTPUT COMPONENT
272
DATA SCHEMA DETECTION COMPONENT
229
OTHER
274

FIG. 4

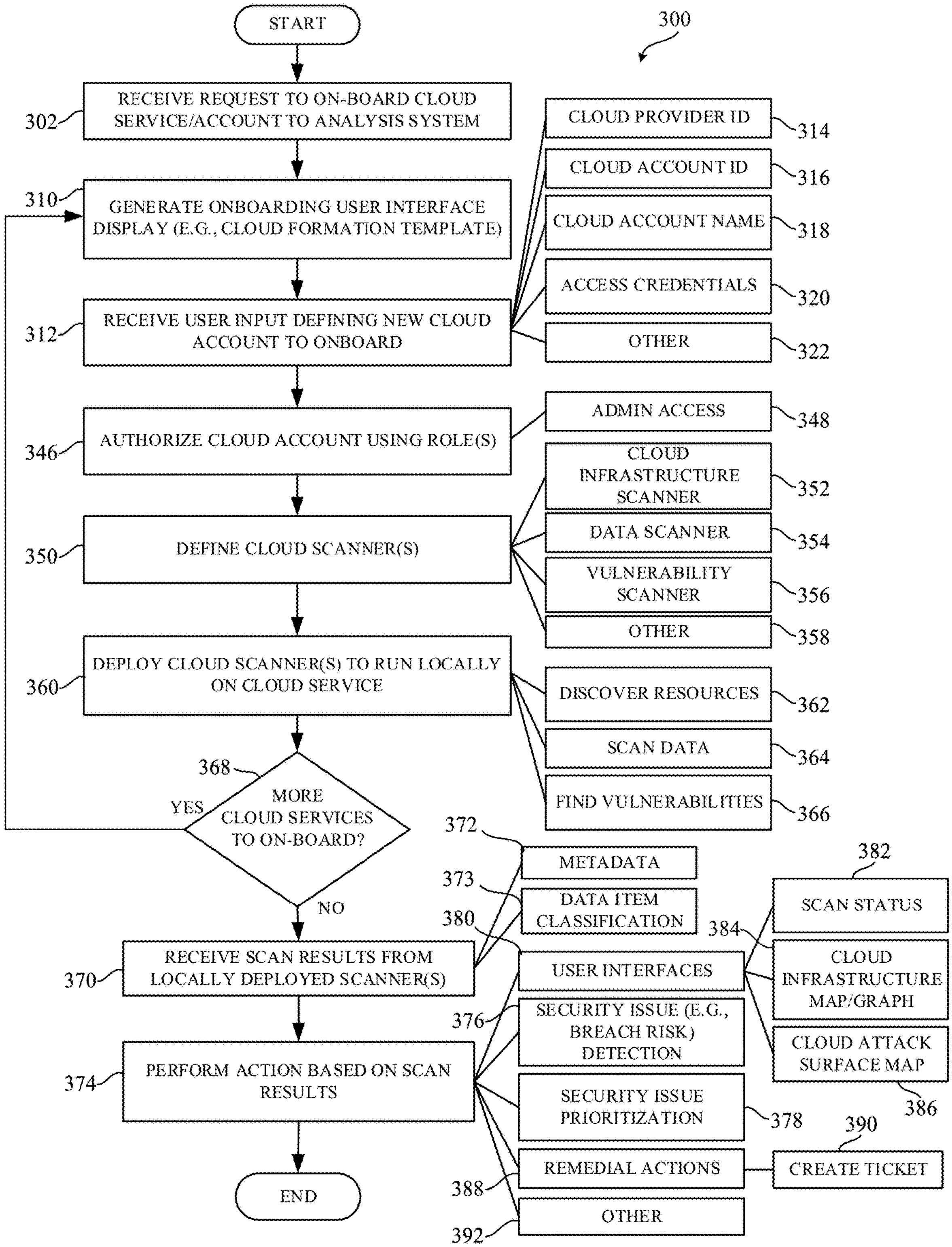

300
START
302
RECEIVE REQUEST TO ON-BOARD CLOUD SERVICE/ACCOUNT TO ANALYSIS SYSTEM
310
GENERATE ONBOARDING USER INTERFACE DISPLAY (E.G., CLOUD FORMATION TEMPLATE)
312
RECEIVE USER INPUT DEFINING NEW CLOUD ACCOUNT TO ONBOARD
CLOUD PROVIDER ID
314
CLOUD ACCOUNT ID
316
CLOUD ACCOUNT NAME
318
ACCESS CREDENTIALS
320
OTHER
322
346
AUTHORIZE CLOUD ACCOUNT USING ROLE(S)
ADMIN ACCESS
348
350
DEFINE CLOUD SCANNER(S)
CLOUD INFRASTRUCTURE SCANNER
352
DATA SCANNER
354
VULNERABILITY SCANNER
356
OTHER
358
360
DEPLOY CLOUD SCANNER(S) TO RUN LOCALLY ON CLOUD SERVICE
DISCOVER RESOURCES
362
SCAN DATA
364
FIND VULNERABILITIES
366
368
MORE CLOUD SERVICES TO ON-BOARD?
YES
NO
370
RECEIVE SCAN RESULTS FROM LOCALLY DEPLOYED SCANNER(S)
372
METADATA
373
DATA ITEM CLASSIFICATION
374
PERFORM ACTION BASED ON SCAN RESULTS
380
USER INTERFACES
376
SECURITY ISSUE (E.G., BREACH RISK) DETECTION
SECURITY ISSUE PRIORITIZATION
378
388
REMEDIAL ACTIONS
392
OTHER
382
SCAN STATUS
384
CLOUD INFRASTRUCTURE MAP/GRAPH
CLOUD ATTACK SURFACE MAP
386
390
CREATE TICKET
END

FIG. 5

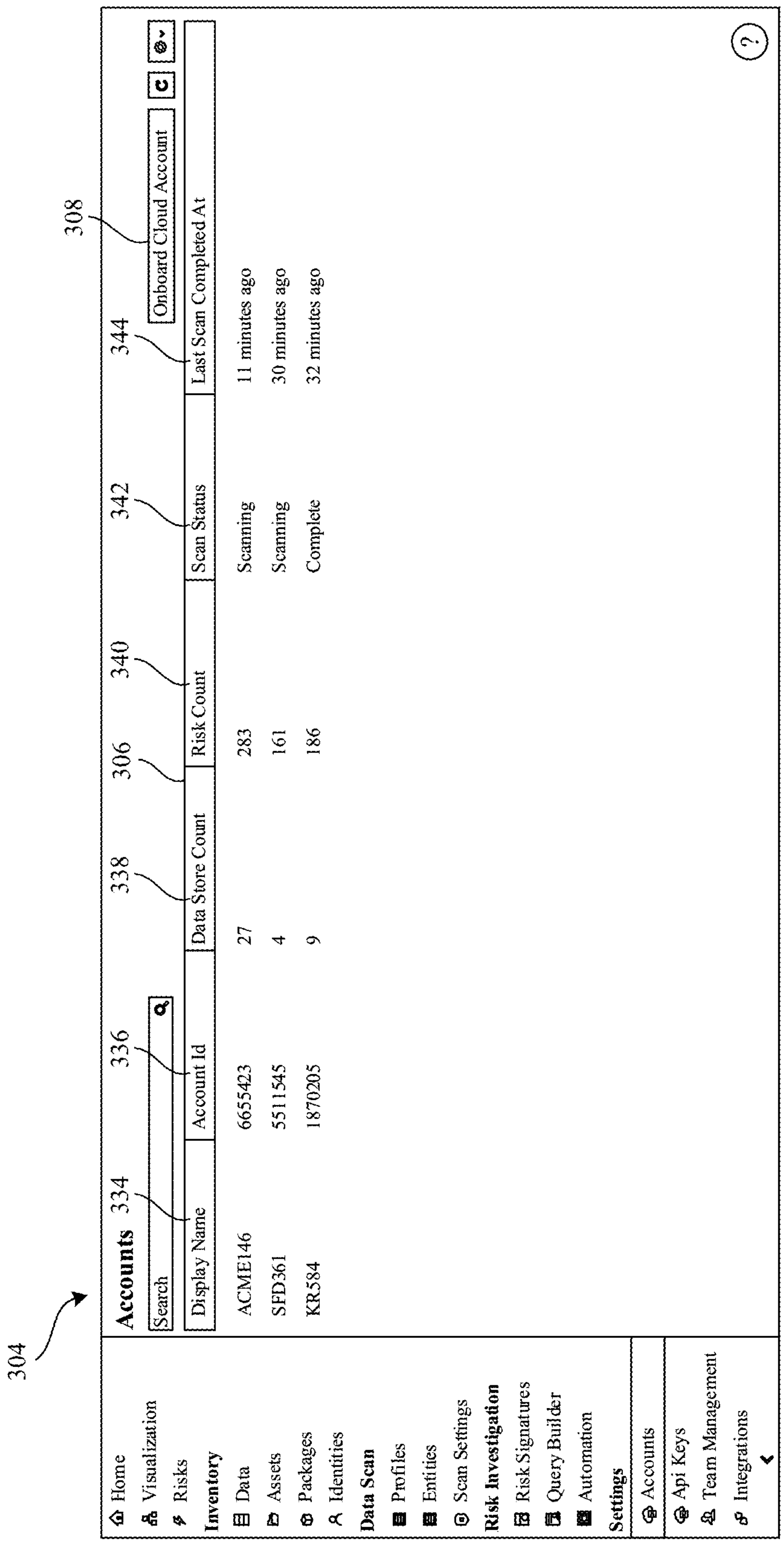

304
308
Accounts
334
336
338
306
340
342
344
Search
Onboard Cloud Account
Display Name
Account Id
Data Store Count
Risk Count
Scan Status
Last Scan Completed At
ACME146
6655423
27
283
Scanning
11 minutes ago
SFD361
5511545
4
161
Scanning
30 minutes ago
KR584
1870205
9
186
Complete
32 minutes ago
Home
Visualization
Risks
Inventory
Data
Assets
Packages
Identities
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Api Keys
Team Management
Integrations
?

FIG. 6

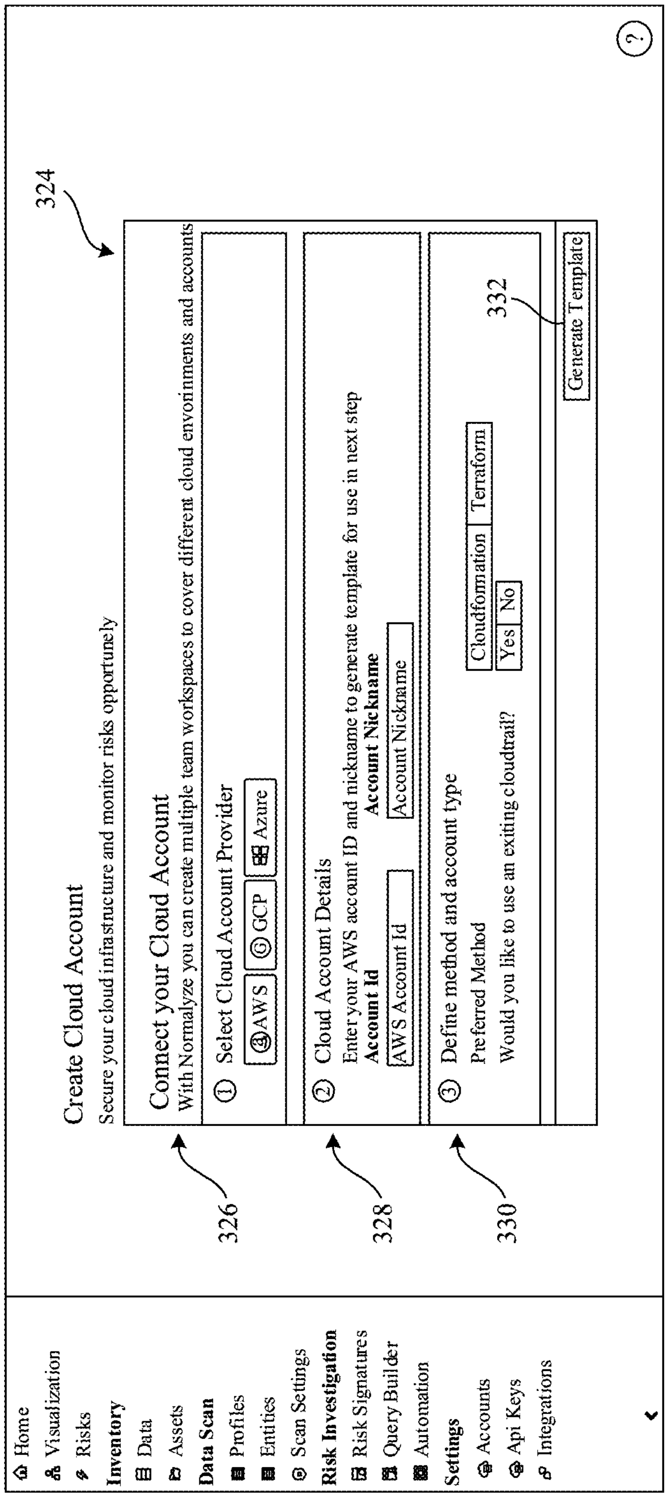

Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Api Keys
Integrations
Create Cloud Account
Secure your cloud infrastructure and monitor risks opportunely
324
Connect your Cloud Account
With Normalyze you can create multiple team workspaces to cover different cloud environments and accounts
326
① Select Cloud Account Provider
AWS
GCP
Azure
328
② Cloud Account Details
Enter your AWS account ID and nickname to generate template for use in next step
Account Id
AWS Account Id
Account Nickname
Account Nickname
330
③ Define method and account type
Preferred Method
Cloudformation
Terraform
Would you like to use an exiting cloudtrail?
Yes
No
332
Generate Template

FIG. 7

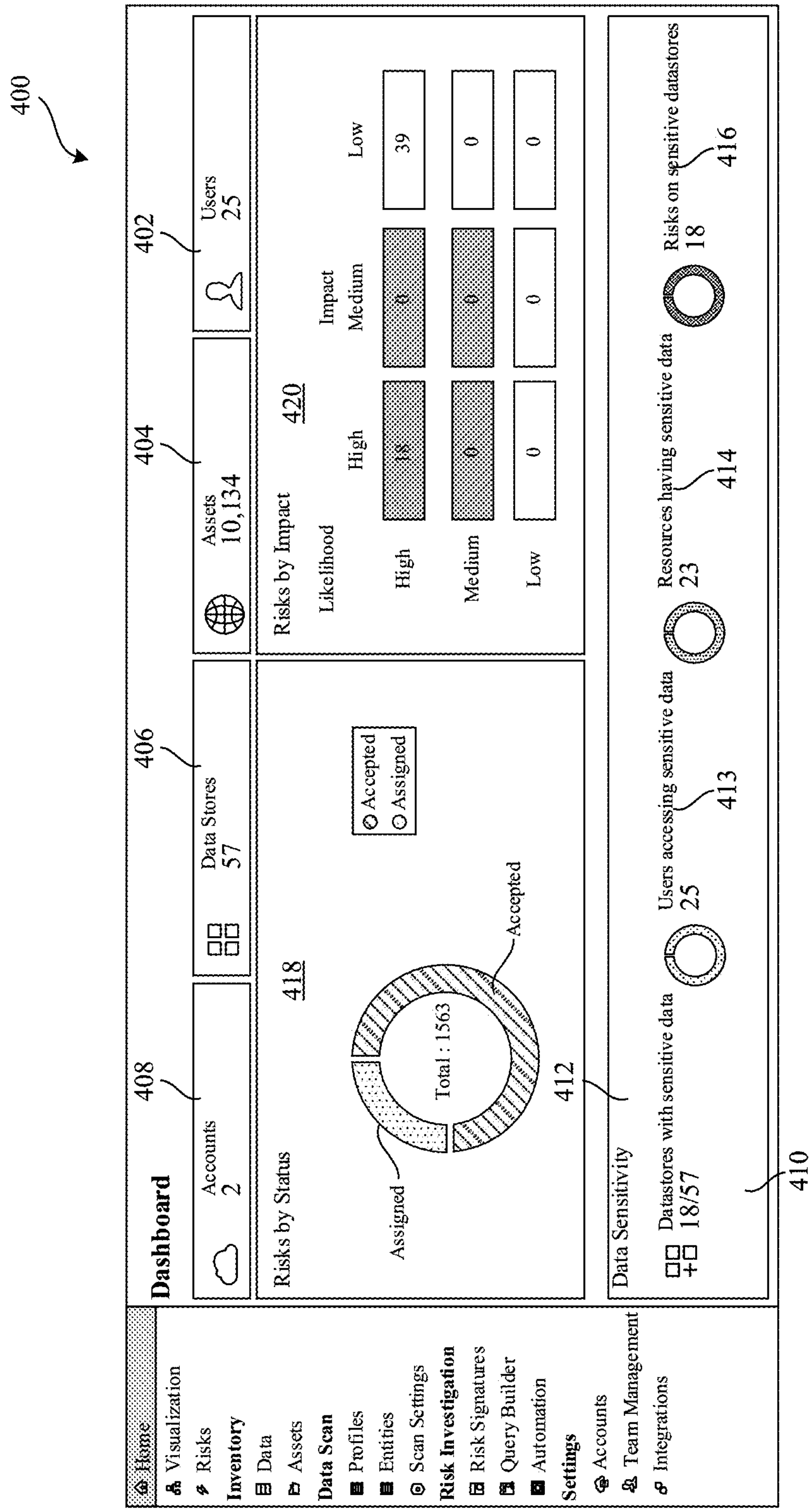

400
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Team Management
Integrations
Dashboard
Accounts
2
408
Data Stores
57
406
Assets
10,134
404
Users
25
402
Risks by Status
418
Accepted
Assigned
Total : 1563
Assigned
Accepted
412
Risks by Impact
420
Impact
Likelihood
High
Medium
Low
18
0
39
0
Data Sensitivity
Datastores with sensitive data
18/57
Users accessing sensitive data
25
413
Resources having sensitive data
23
414
Risks on sensitive datastores
18
416
410

FIG. 8

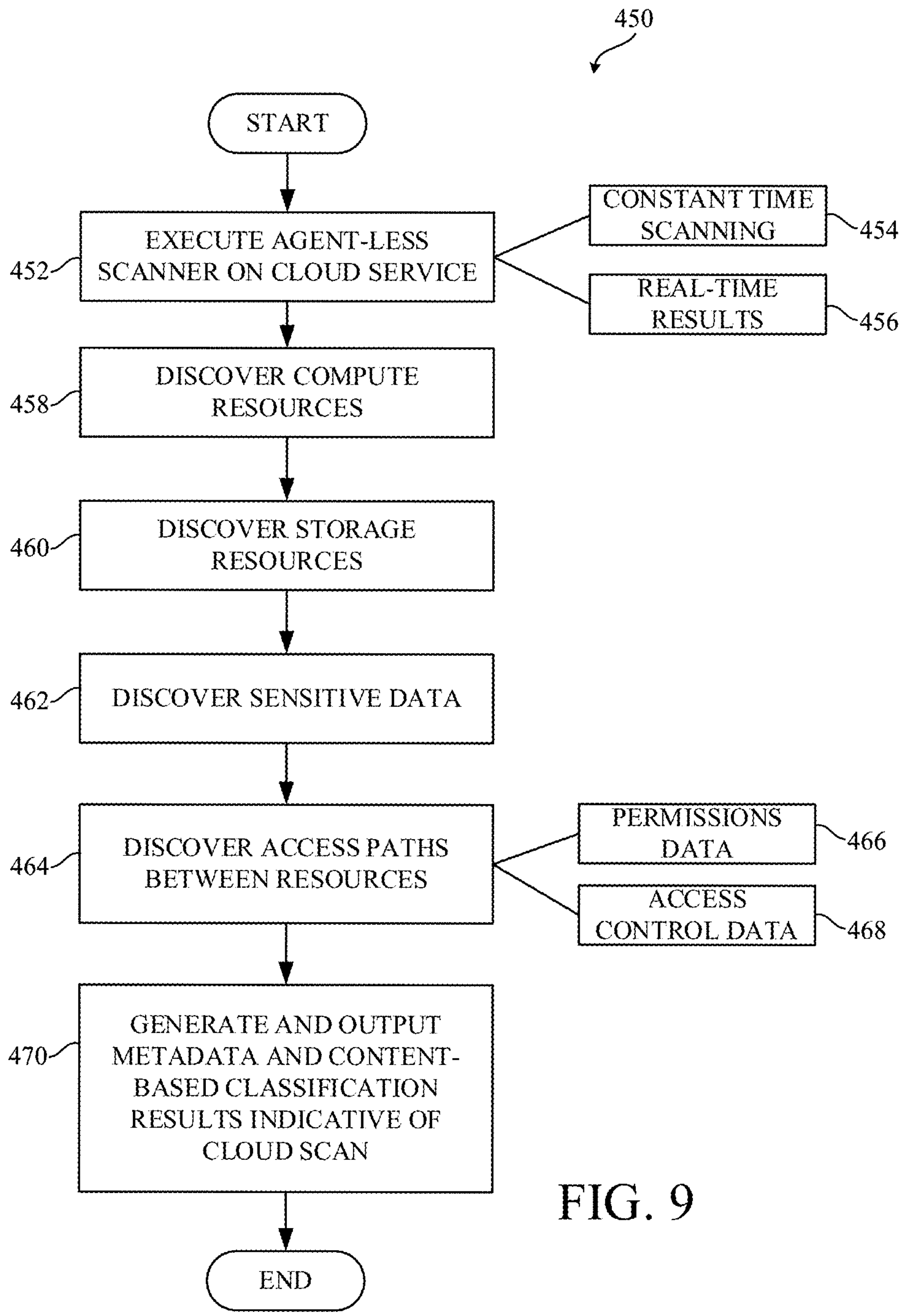

450
START
452
EXECUTE AGENT-LESS SCANNER ON CLOUD SERVICE
CONSTANT TIME SCANNING
454
REAL-TIME RESULTS
456
458
DISCOVER COMPUTE RESOURCES
460
DISCOVER STORAGE RESOURCES
462
DISCOVER SENSITIVE DATA
464
DISCOVER ACCESS PATHS BETWEEN RESOURCES
PERMISSIONS DATA
466
ACCESS CONTROL DATA
468
470
GENERATE AND OUTPUT METADATA AND CONTENT-BASED CLASSIFICATION RESULTS INDICATIVE OF CLOUD SCAN
END

FIG. 9

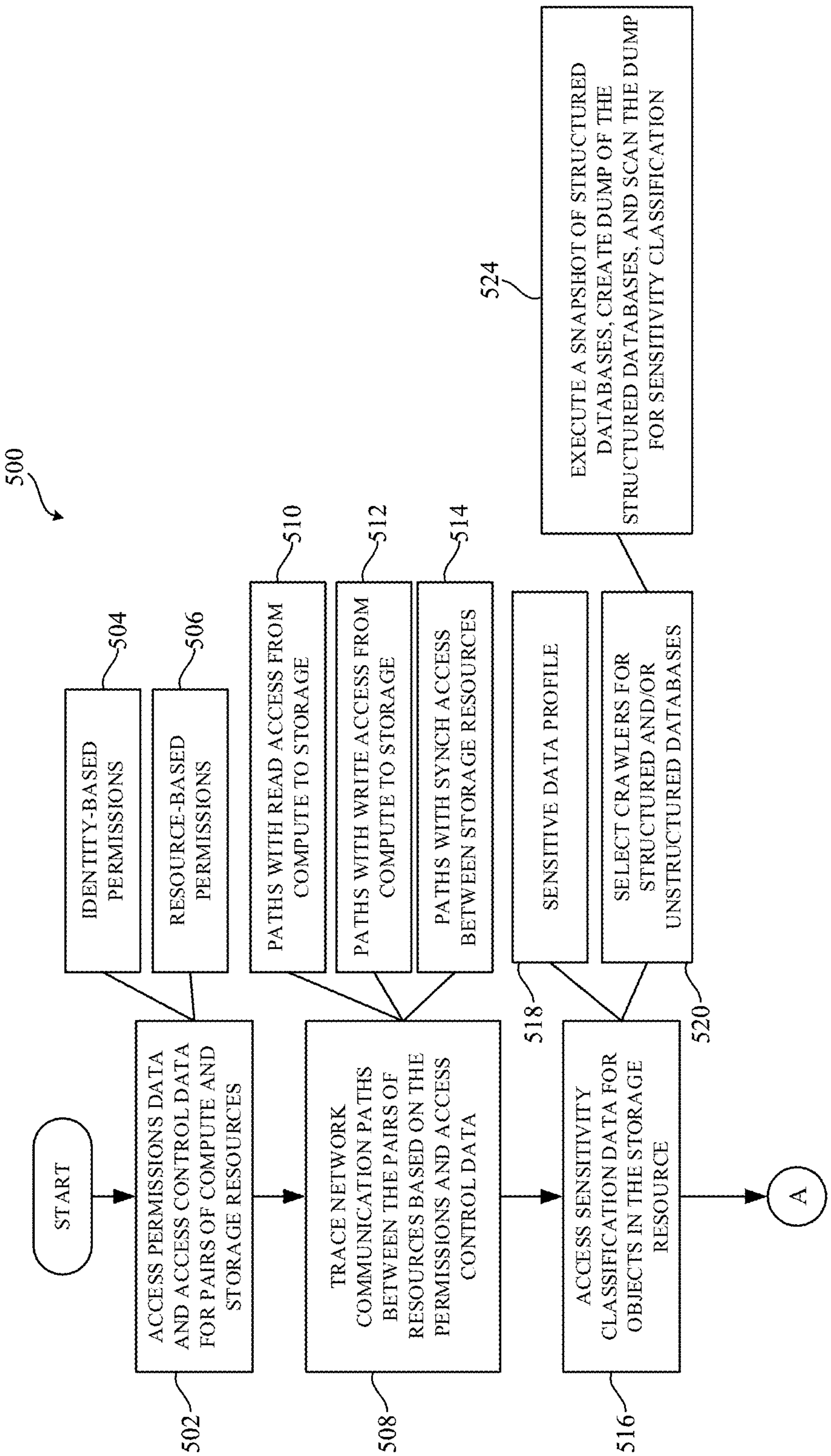

500
START
502
ACCESS PERMISSIONS DATA AND ACCESS CONTROL DATA FOR PAIRS OF COMPUTE AND STORAGE RESOURCES
504
IDENTITY-BASED PERMISSIONS
506
RESOURCE-BASED PERMISSIONS
508
TRACE NETWORK COMMUNICATION PATHS BETWEEN THE PAIRS OF RESOURCES BASED ON THE PERMISSIONS AND ACCESS CONTROL DATA
510
PATHS WITH READ ACCESS FROM COMPUTE TO STORAGE
512
PATHS WITH WRITE ACCESS FROM COMPUTE TO STORAGE
514
PATHS WITH SYNCH ACCESS BETWEEN STORAGE RESOURCES
516
ACCESS SENSITIVITY CLASSIFICATION DATA FOR OBJECTS IN THE STORAGE RESOURCE
518
SENSITIVE DATA PROFILE
520
SELECT CRAWLERS FOR STRUCTURED AND/OR UNSTRUCTURED DATABASES
524
EXECUTE A SNAPSHOT OF STRUCTURED DATABASES, CREATE DUMP OF THE STRUCTURED DATABASES, AND SCAN THE DUMP FOR SENSITIVITY CLASSIFICATION
A

FIG. 10-1

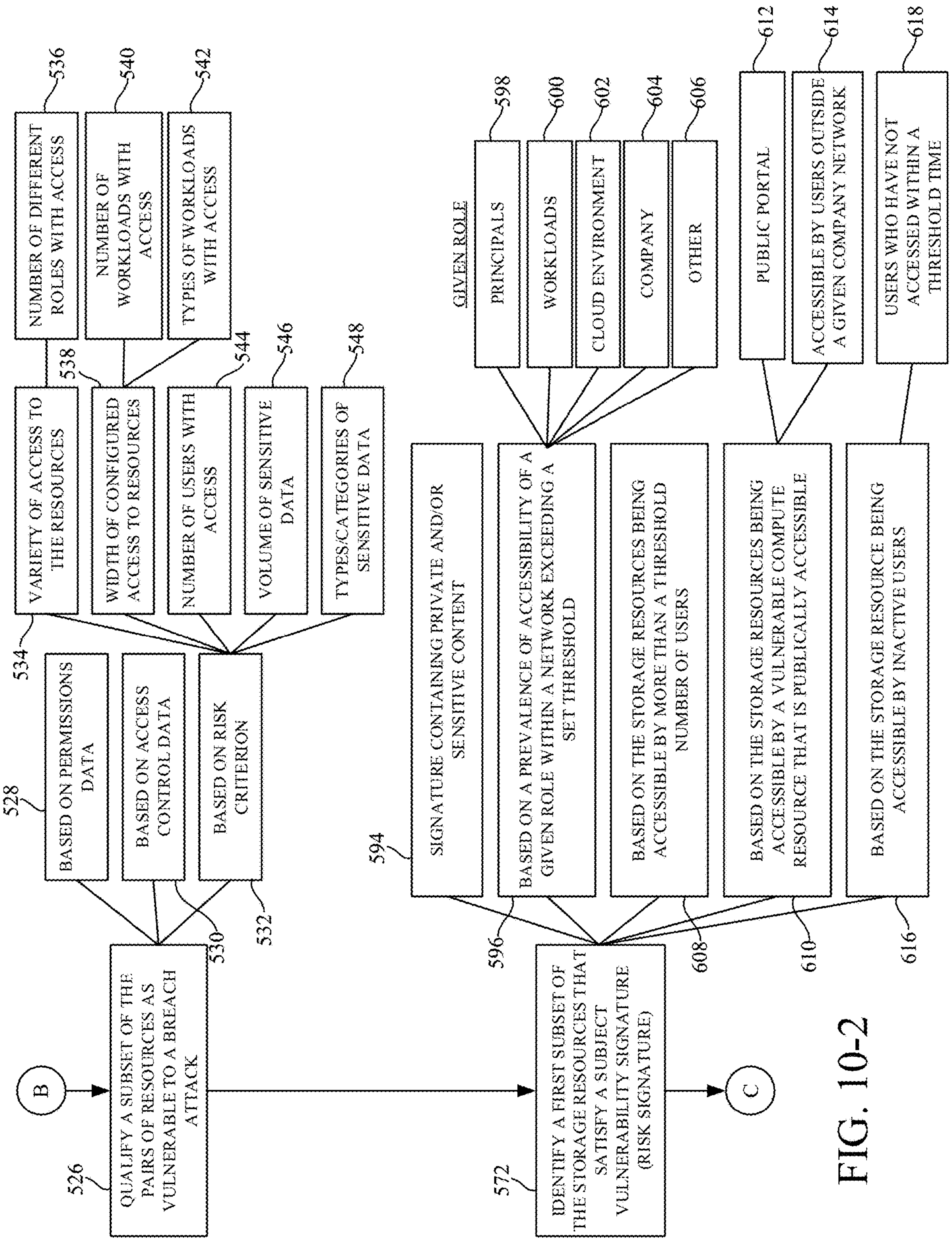

B
526
QUALIFY A SUBSET OF THE PAIRS OF RESOURCES AS VULNERABLE TO A BREACH ATTACK
528
BASED ON PERMISSIONS DATA
530
BASED ON ACCESS CONTROL DATA
532
BASED ON RISK CRITERION
534
VARIETY OF ACCESS TO THE RESOURCES
536
NUMBER OF DIFFERENT ROLES WITH ACCESS
538
WIDTH OF CONFIGURED ACCESS TO RESOURCES
540
NUMBER OF WORKLOADS WITH ACCESS
542
TYPES OF WORKLOADS WITH ACCESS
544
NUMBER OF USERS WITH ACCESS
546
VOLUME OF SENSITIVE DATA
548
TYPES/CATEGORIES OF SENSITIVE DATA
572
IDENTIFY A FIRST SUBSET OF THE STORAGE RESOURCES THAT SATISFY A SUBJECT VULNERABILITY SIGNATURE (RISK SIGNATURE)
594
SIGNATURE CONTAINING PRIVATE AND/OR SENSITIVE CONTENT
596
BASED ON A PREVALENCE OF ACCESSIBILITY OF A GIVEN ROLE WITHIN A NETWORK EXCEEDING A SET THRESHOLD
GIVEN ROLE
598
PRINCIPALS
600
WORKLOADS
602
CLOUD ENVIRONMENT
604
COMPANY
606
OTHER
608
BASED ON THE STORAGE RESOURCES BEING ACCESSIBLE BY MORE THAN A THRESHOLD NUMBER OF USERS
610
BASED ON THE STORAGE RESOURCES BEING ACCESSIBLE BY A VULNERABLE COMPUTE RESOURCE THAT IS PUBLICALLY ACCESSIBLE
612
PUBLIC PORTAL
614
ACCESSIBLE BY USERS OUTSIDE A GIVEN COMPANY NETWORK
616
BASED ON THE STORAGE RESOURCE BEING ACCESSIBLE BY INACTIVE USERS
618
USERS WHO HAVE NOT ACCESSED WITHIN A THRESHOLD TIME
C

FIG. 10-2

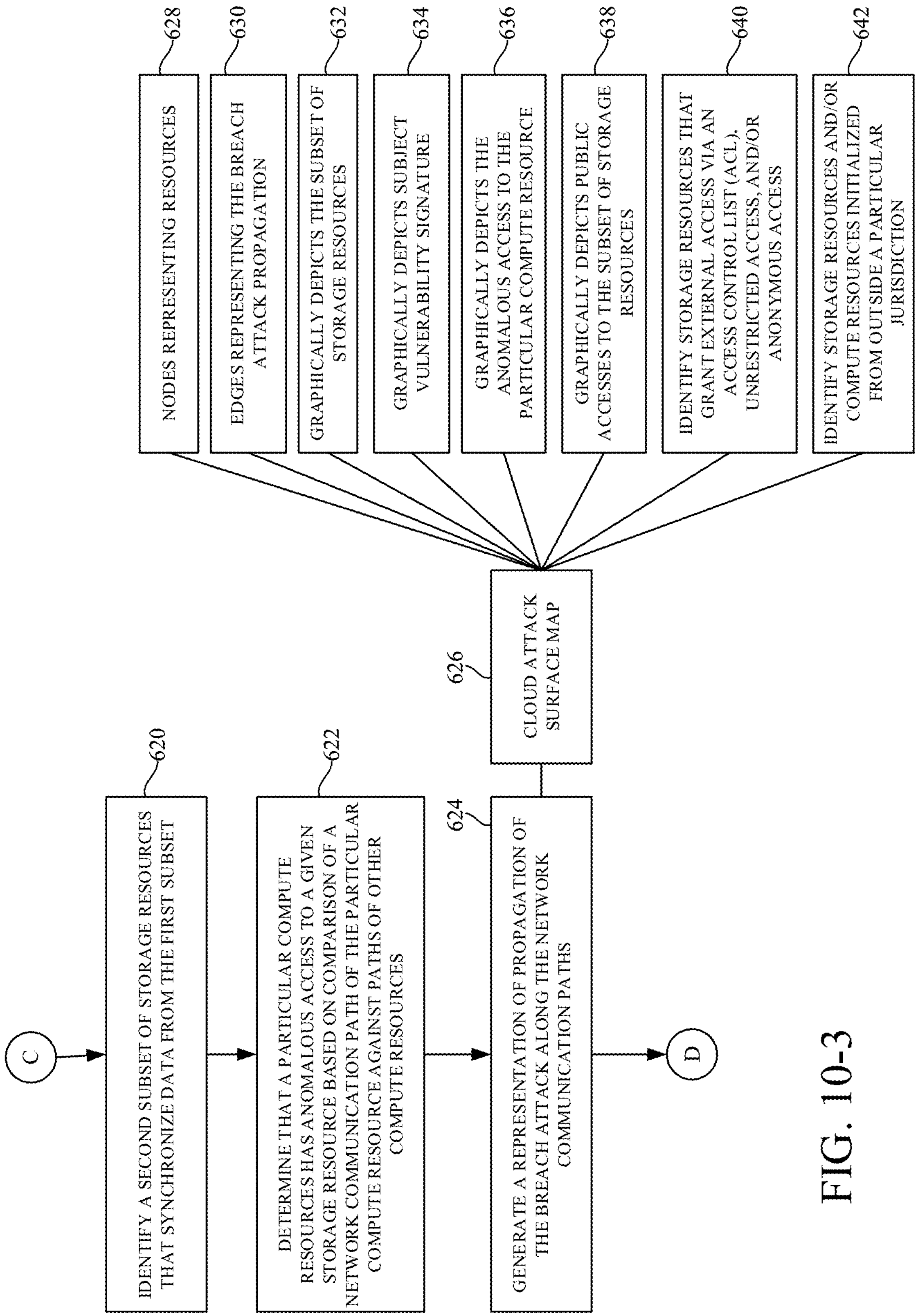

C
IDENTIFY A SECOND SUBSET OF STORAGE RESOURCES THAT SYNCHRONIZE DATA FROM THE FIRST SUBSET
620
DETERMINE THAT A PARTICULAR COMPUTE RESOURCES HAS ANOMALOUS ACCESS TO A GIVEN STORAGE RESOURCE BASED ON COMPARISON OF A NETWORK COMMUNICATION PATH OF THE PARTICULAR COMPUTE RESOURCE AGAINST PATHS OF OTHER COMPUTE RESOURCES
622
GENERATE A REPRESENTATION OF PROPAGATION OF THE BREACH ATTACK ALONG THE NETWORK COMMUNICATION PATHS
624
D
CLOUD ATTACK SURFACE MAP
626
NODES REPRESENTING RESOURCES
628
EDGES REPRESENTING THE BREACH ATTACK PROPAGATION
630
GRAPHICALLY DEPICTS THE SUBSET OF STORAGE RESOURCES
632
GRAPHICALLY DEPICTS SUBJECT VULNERABILITY SIGNATURE
634
GRAPHICALLY DEPICTS THE ANOMALOUS ACCESS TO THE PARTICULAR COMPUTE RESOURCE
636
GRAPHICALLY DEPICTS PUBLIC ACCESSES TO THE SUBSET OF STORAGE RESOURCES
638
IDENTIFY STORAGE RESOURCES THAT GRANT EXTERNAL ACCESS VIA AN ACCESS CONTROL LIST (ACL), UNRESTRICTED ACCESS, AND/OR ANONYMOUS ACCESS
640
IDENTIFY STORAGE RESOURCES AND/OR COMPUTE RESOURCES INITIALIZED FROM OUTSIDE A PARTICULAR JURISDICTION
642

FIG. 10-3

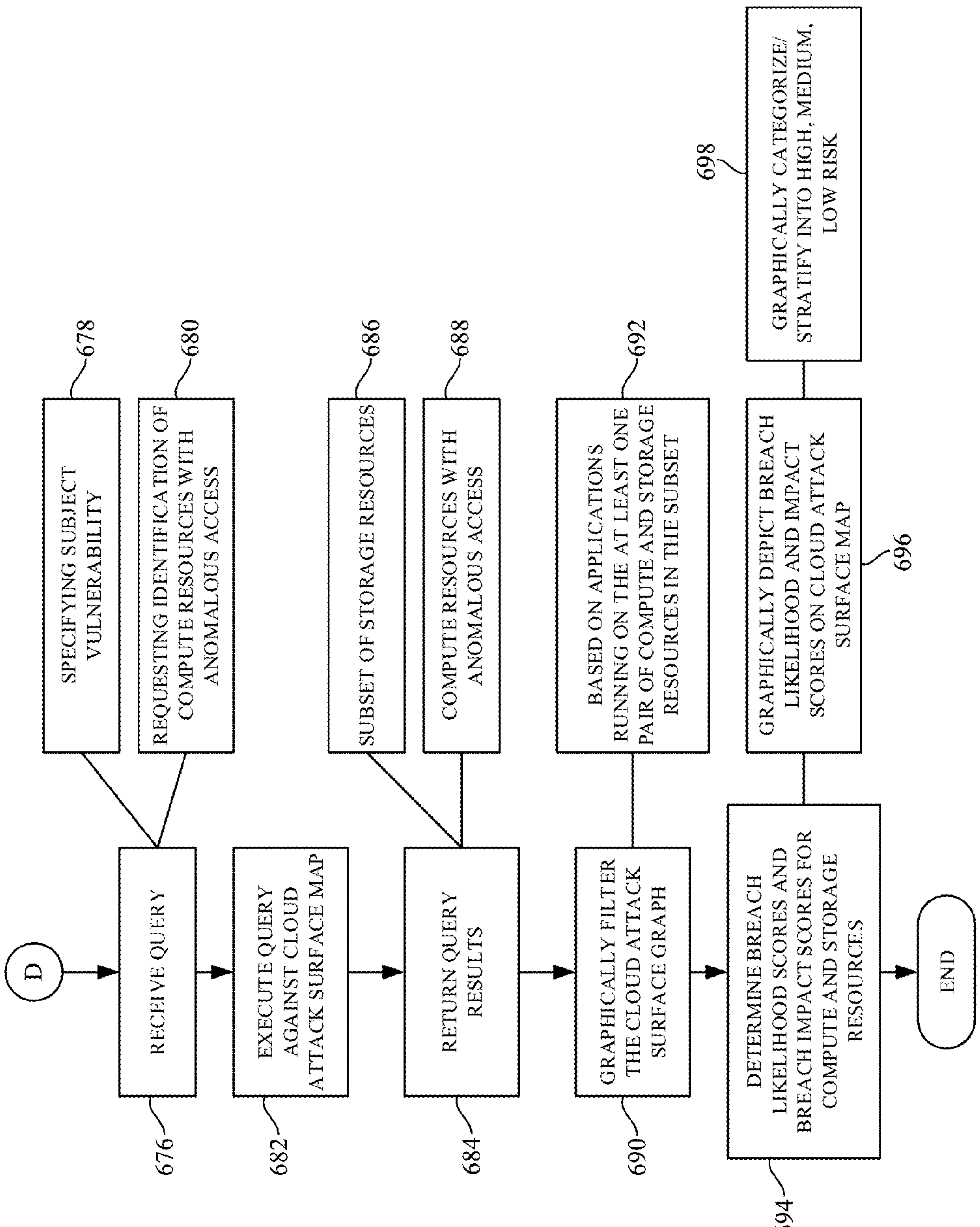

D
RECEIVE QUERY
676
SPECIFYING SUBJECT VULNERABILITY
678
REQUESTING IDENTIFICATION OF COMPUTE RESOURCES WITH ANOMALOUS ACCESS
680
EXECUTE QUERY AGAINST CLOUD ATTACK SURFACE MAP
682
RETURN QUERY RESULTS
684
SUBSET OF STORAGE RESOURCES
686
COMPUTE RESOURCES WITH ANOMALOUS ACCESS
688
GRAPHICALLY FILTER THE CLOUD ATTACK SURFACE GRAPH
690
BASED ON APPLICATIONS RUNNING ON THE AT LEAST ONE PAIR OF COMPUTE AND STORAGE RESOURCES IN THE SUBSET
692
DETERMINE BREACH LIKELIHOOD SCORES AND BREACH IMPACT SCORES FOR COMPUTE AND STORAGE RESOURCES
694
GRAPHICALLY DEPICT BREACH LIKELIHOOD AND IMPACT SCORES ON CLOUD ATTACK SURFACE MAP
696
GRAPHICALLY CATEGORIZE/ STRATIFY INTO HIGH, MEDIUM, LOW RISK
698
END

FIG. 10-4

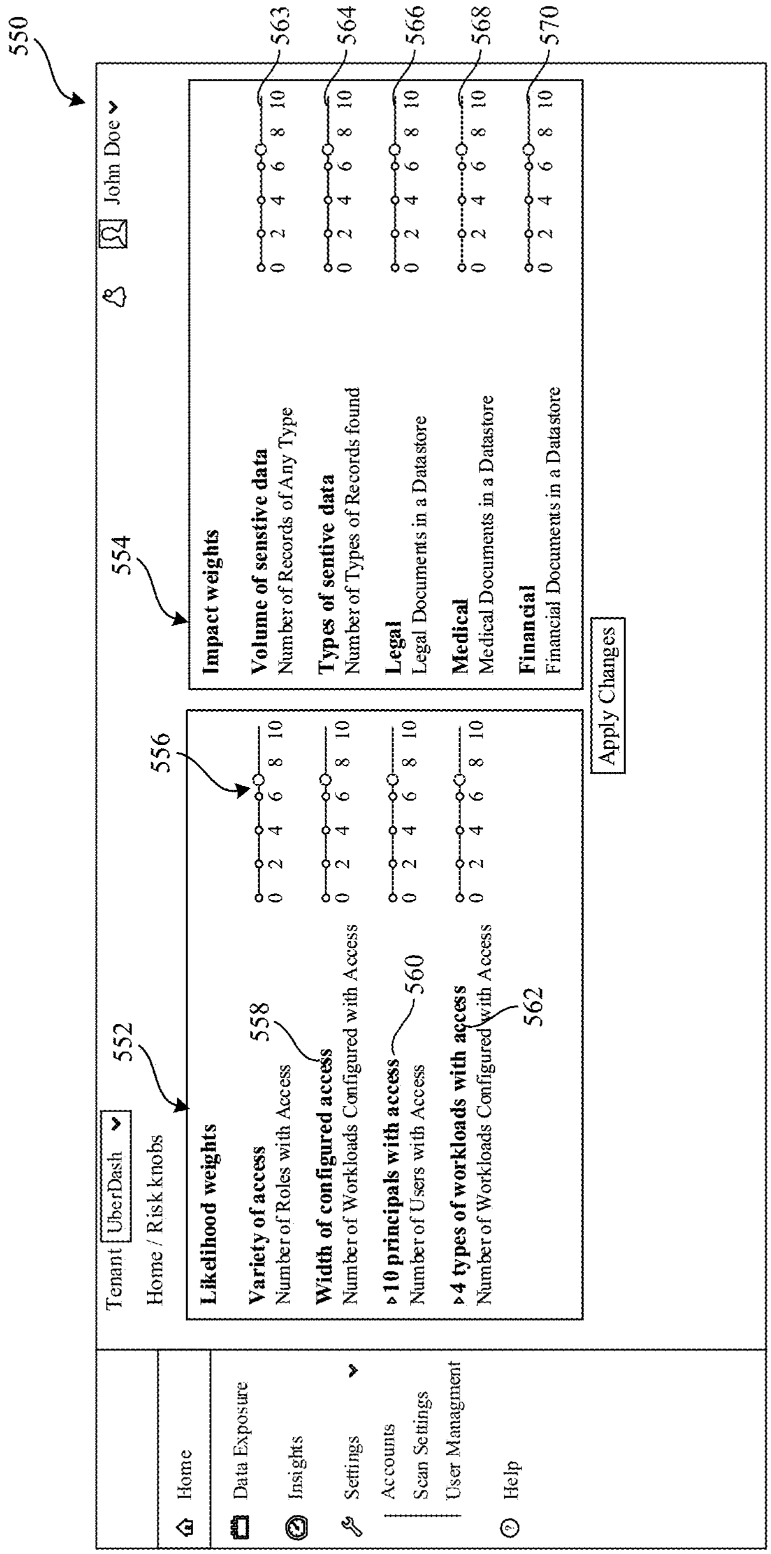
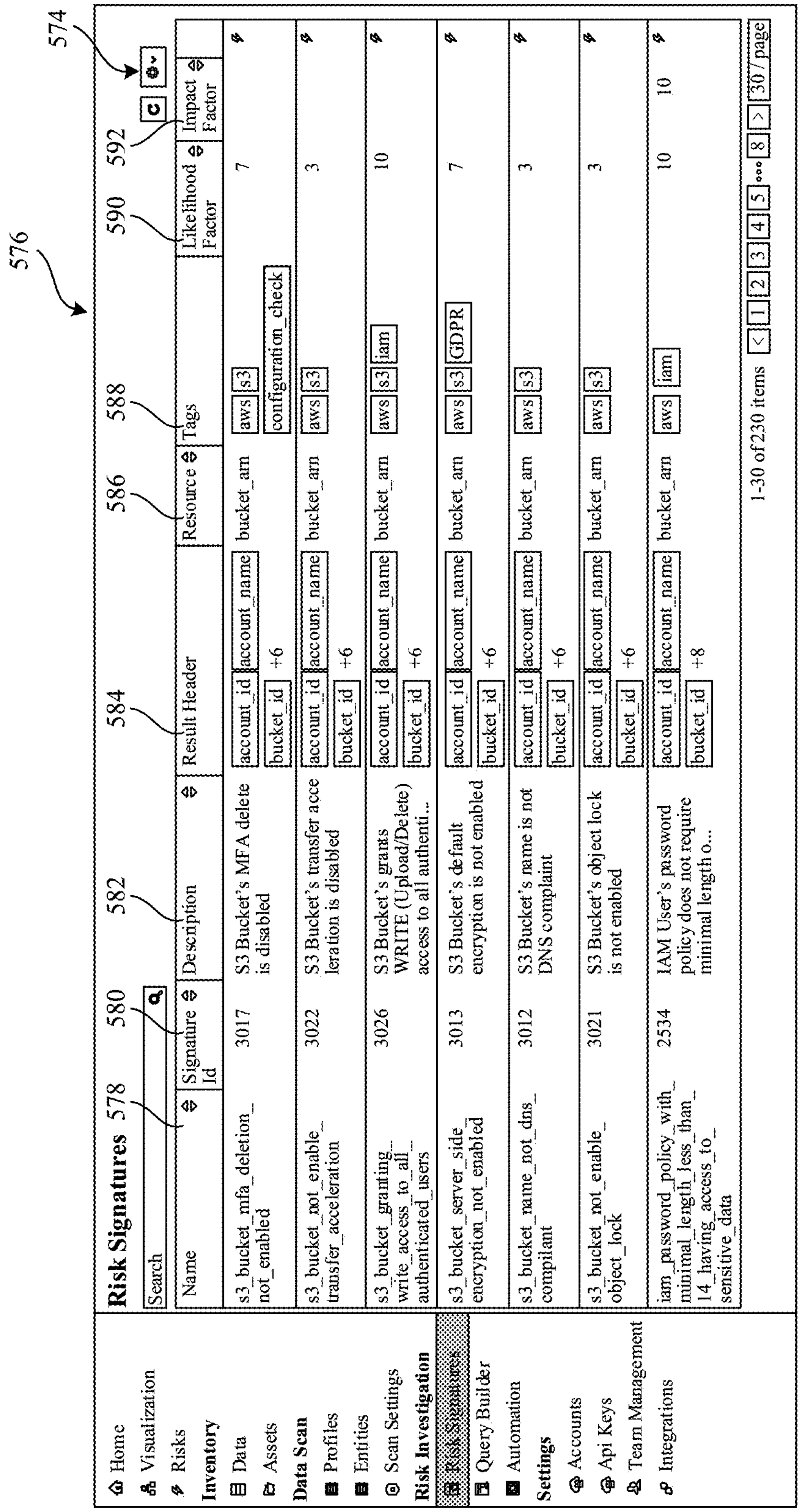

550
Home
Data Exposure
Insights
Settings
Accounts
Scan Settings
User Managment
Help
Tenant UberDash
Home / Risk knobs
John Doe
552
Likelihood weights
Variety of access
Number of Roles with Access
558
Width of configured access
Number of Workloads Configured with Access
▸10 principals with access
560
Number of Users with Access
▸4 types of workloads with access
Number of Workloads Configured with Access
562
556
0 2 4 6 8 10
554
Impact weights
Volume of senstive data
Number of Records of Any Type
Types of sentive data
Number of Types of Records found
Legal
Legal Documents in a Datastore
Medical
Medical Documents in a Datastore
Financial
Financial Documents in a Datastore
563
564
566
568
570
Apply Changes

FIG. 11



574
576
578
580
582
584
586
588
590
592
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Api Keys
Team Management
Integrations
Risk Signatures
Search
Name
Signature Id
Description
Result Header
Resource
Tags
Likelihood Factor
Impact Factor
s3_bucket_mfa_deletion_not_enabled
3017
S3 Bucket's MFA delete is disabled
account_id account_name bucket_id +6
bucket_arn
aws s3 configuration_check
7
s3_bucket_not_enable_transfer_acceleration
3022
S3 Bucket's transfer acceleration is disabled
account_id account_name bucket_id +6
bucket_arn
aws s3
3
s3_bucket_granting_write_access_to_all_authenticated_users
3026
S3 Bucket's grants WRITE (Upload/Delete) access to all authenti...
account_id account_name bucket_id +6
bucket_arn
aws s3 iam
10
s3_bucket_server_side encryption_not_enabled
3013
S3 Bucket's default encryption is not enabled
account_id account_name bucket_id +6
bucket_arn
aws s3 GDPR
7
s3_bucket_name_not_dns_compilant
3012
S3 Bucket's name is not DNS complaint
account_id account_name bucket_id +6
bucket_arn
aws s3
3
s3_bucket_not_enable_object_lock
3021
S3 Bucket's object lock is not enabled
account_id account_name bucket_id +6
bucket_arn
aws s3
3
iam_password_policy_with_minimal_length_less_than_14_having_access_to_sensitive_data
2534
IAM User's password policy does not require minimal length o...
account_id account_name bucket_id +8
bucket_arn
aws iam
10
10
1-30 of 230 items
1 2 3 4 5 ••• 8
30 / page

FIG. 12

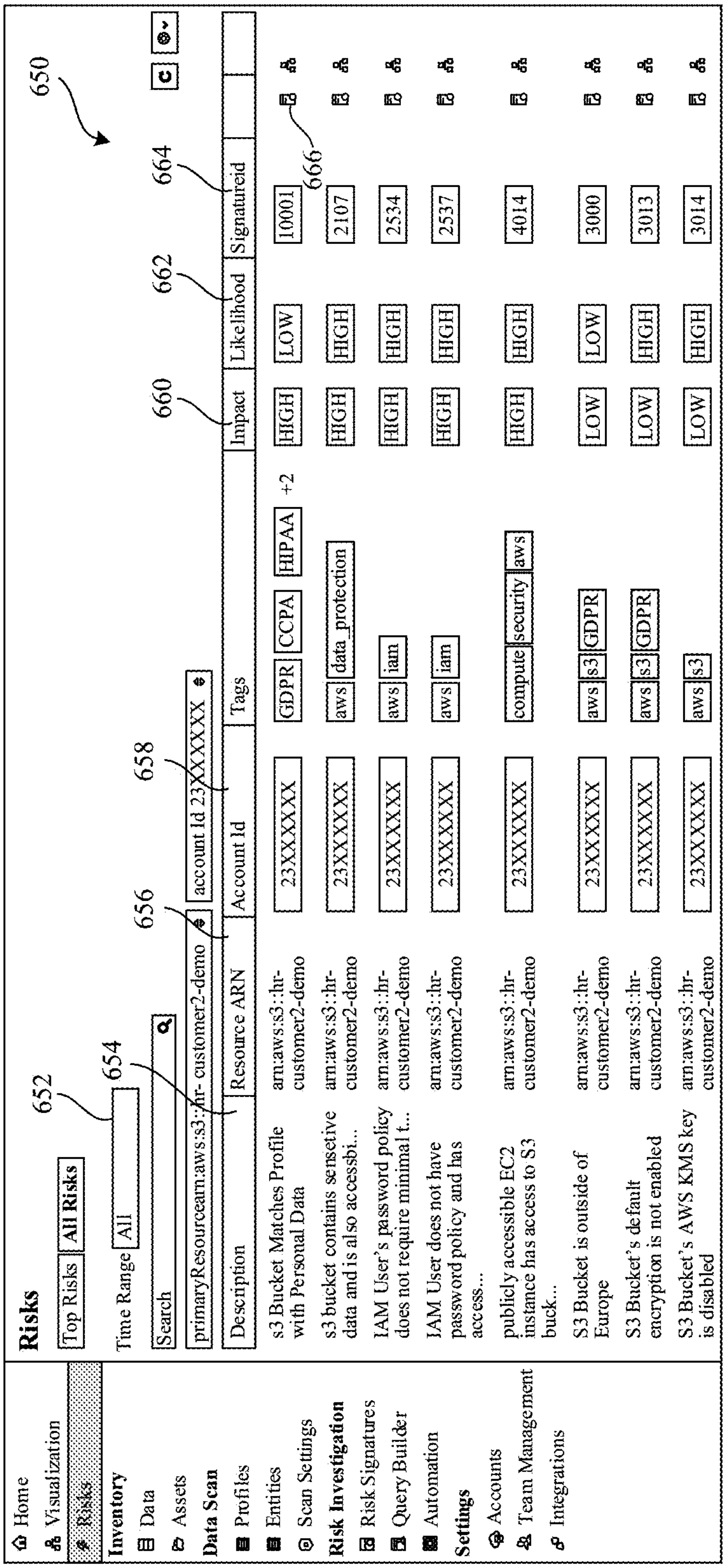

650
652
654
656
658
660
662
664
666
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Team Management
Integrations
Risks
Top Risks
All Risks
Time Range
All
Search
primaryResourcearn:aws:s3::hr- customer2-demo
account Id 23XXXXXX
Description
Resource ARN
Account Id
Tags
Impact
Likelihood
Signatureid
s3 Bucket Matches Profile with Personal Data
arn:aws:s3::hr-customer2-demo
23XXXXXX
GDPR
CCPA
HIPAA
+2
HIGH
LOW
10001
s3 bucket contains sensetive data and is also accessbi...
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
data_protection
HIGH
HIGH
2107
IAM User's password policy does not require minimal t...
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
iam
HIGH
HIGH
2534
IAM User does not have password policy and has access...
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
iam
HIGH
HIGH
2537
publicly accessible EC2 instance has access to S3 buck...
arn:aws:s3::hr-customer2-demo
23XXXXXX
compute
security
aws
HIGH
HIGH
4014
S3 Bucket is outside of Europe
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
s3
GDPR
LOW
LOW
3000
S3 Bucket's default encryption is not enabled
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
s3
GDPR
LOW
HIGH
3013
S3 Bucket's AWS KMS key is disabled
arn:aws:s3::hr-customer2-demo
23XXXXXX
aws
s3
LOW
HIGH
3014

FIG. 13

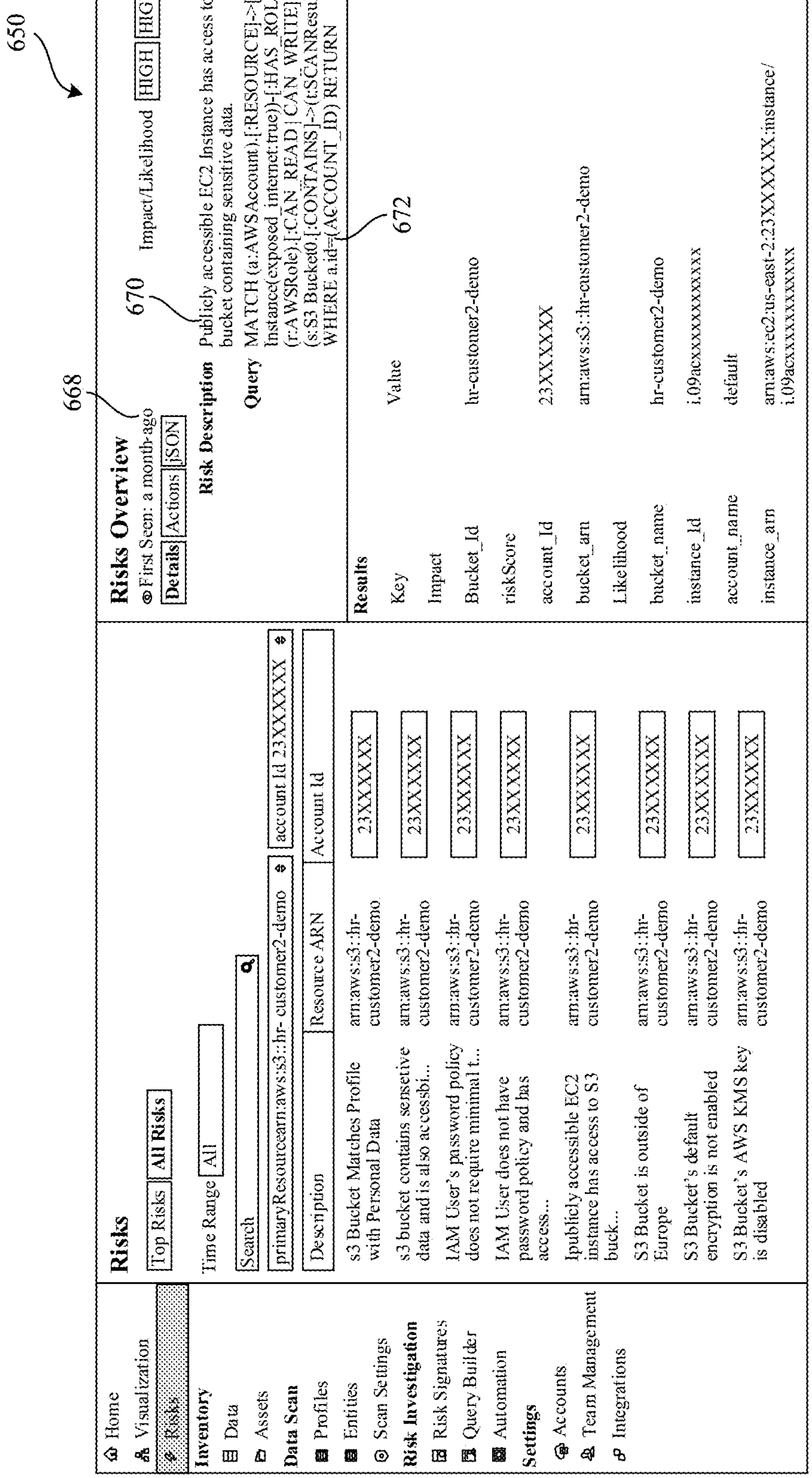

650
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automation
Settings
Accounts
Team Management
Integrations
Risks
Top Risks
All Risks
Time Range
All
Search
primaryResourcearn:aws:s3::hr- customer2-demo
account Id 23XXXXXX
Description
Resource ARN
Account Id
s3 Bucket Matches Profile with Personal Data
s3 bucket contains sensetive data and is also accessbi...
IAM User's password policy does not require minimal t...
IAM User does not have password policy and has access...
Ipublicly accessible EC2 instance has access to S3 buck...
S3 Bucket is outside of Europe
S3 Bucket's default encryption is not enabled
S3 Bucket's AWS KMS key is disabled
arn:aws:s3::hr-customer2-demo
23XXXXXX
Risks Overview
First Seen: a month ago
668
Details
Actions
JSON
Impact/Likelihood
HIGH
HIGH
670
Risk Description
Publicly accessible EC2 Instance has access to S3 bucket containing sensitive data.
Query
MATCH (a:AWSAccount),[:RESOURCE]->[i:EC2 Instance(exposed_internet:true)]-[:HAS_ROLE]->(r:AWSRole),[:CAN_READ|CAN_WRITE]->(s:S3 Bucket0,[:CONTAINS]->(t:SCANResult) WHERE a.id=(ACCOUNT_ID) RETURN
672
Results
Key
Value
Impact
Bucket_Id
hr-customer2-demo
riskScore
account_Id
23XXXXXX
bucket_arn
arn:aws:s3::hr-customer2-demo
Likelihood
bucket_name
hr-customer2-demo
instance_Id
i.09acxxxxxxxxxxxx
account_name
default
instance_arn
arn:aws:ec2:us-east-2:23XXXXXX:instance/i.09acxxxxxxxxxxxx

FIG. 14

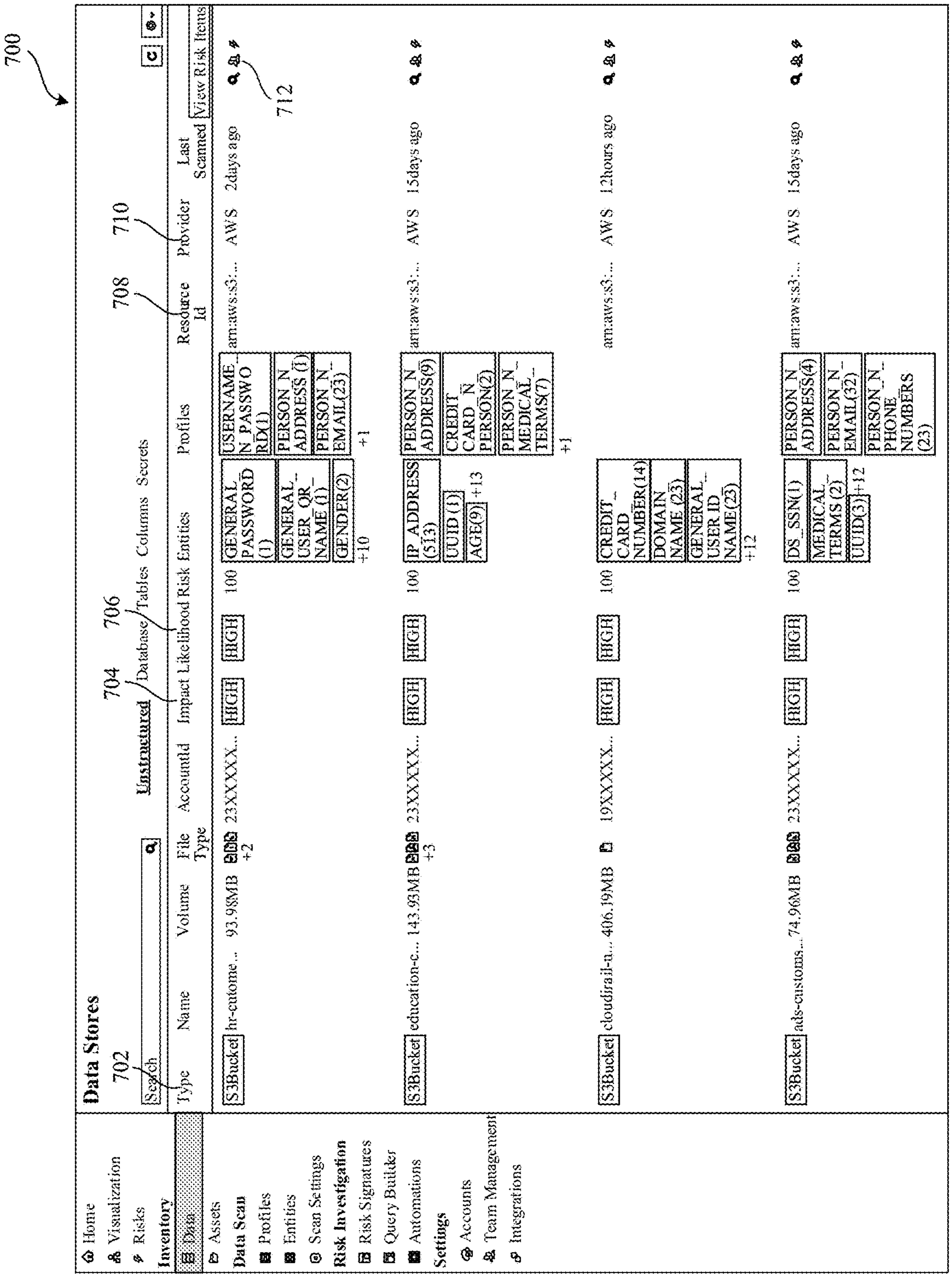

700
Data Stores
702
Search
Unstructured
Database
Tables
Columns
Secrets
704
706
708
710
712
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automations
Settings
Accounts
Team Management
Integrations
Type
Name
Volume
File Type
AccountId
Impact
Likelihood
Risk
Entities
Profiles
Resource Id
Provider
Last Scanned
View Risk Items
S3Bucket
hr-cutome...
93.98MB
+2
23XXXXX...
HIGH
100
GENERAL_PASSWORD (1)
GENERAL_USER_OR_NAME (1)
GENDER(2)
+10
USERNAME_N_PASSWORD(1)
PERSON_N_ADDRESS (1)
PERSON_N_EMAIL(23)
+1
arn:aws:s3:...
AWS
2days ago
education-c...
143.93MB
+3
IP_ADDRESS (513)
UUID (1)
AGE(9)
+13
PERSON_N_ADDRESS(9)
CREDIT_CARD_N_PERSON(2)
PERSON_N_MEDICAL_TERMS(7)
15days ago
cloudirail-u...
406.19MB
19XXXXX...
CREDIT_CARD_NUMBER(14)
DOMAIN_NAME (23)
GENERAL_USER ID_NAME(23)
+12
12hours ago
ads-customs...
74.96MB
DS_SSN(1)
MEDICAL_TERMS (2)
UUID(3)
PERSON_N_ADDRESS(4)
PERSON_N_EMAIL(32)
PERSON_N_PHONE_NUMBERS (23)

FIG. 15

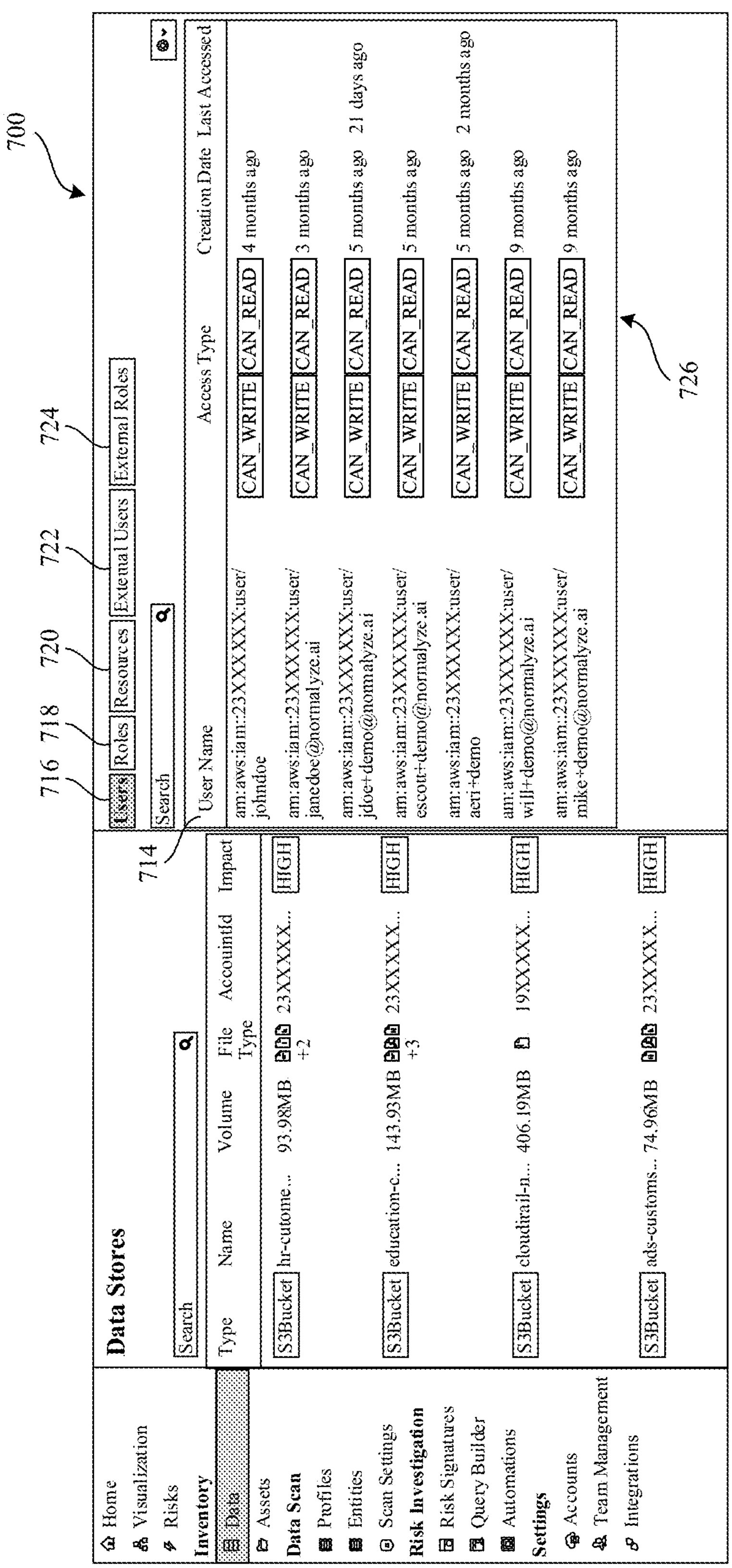

700
Home
Visualization
Risks
Inventory
Data
Assets
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automations
Settings
Accounts
Team Management
Integrations
Data Stores
Search
Type
Name
Volume
File Type
AccountId
Impact
S3Bucket
hr-cutome...
93.98MB
+2
23XXXXX...
HIGH
education-c...
143.93MB
+3
cloudtrail-n...
406.19MB
19XXXXX...
ads-customs...
74.96MB
714
716
718
720
722
724
Users
Roles
Resources
External Users
External Roles
User Name
Access Type
Creation Date
Last Accessed
arn:aws:iam::23XXXXXX:user/johndoe
arn:aws:iam::23XXXXXX:user/janedoe@normalyze.ai
arn:aws:iam::23XXXXXX:user/jdoe+demo@normalyze.ai
arn:aws:iam::23XXXXXX:user/escott+demo@normalyze.ai
arn:aws:iam::23XXXXXX:user/aeri+demo
arn:aws:iam::23XXXXXX:user/will+demo@normalyze.ai
arn:aws:iam::23XXXXXX:user/mike+demo@normalyze.ai
CAN_WRITE
CAN_READ
4 months ago
3 months ago
5 months ago
21 days ago
2 months ago
9 months ago
726

FIG. 16

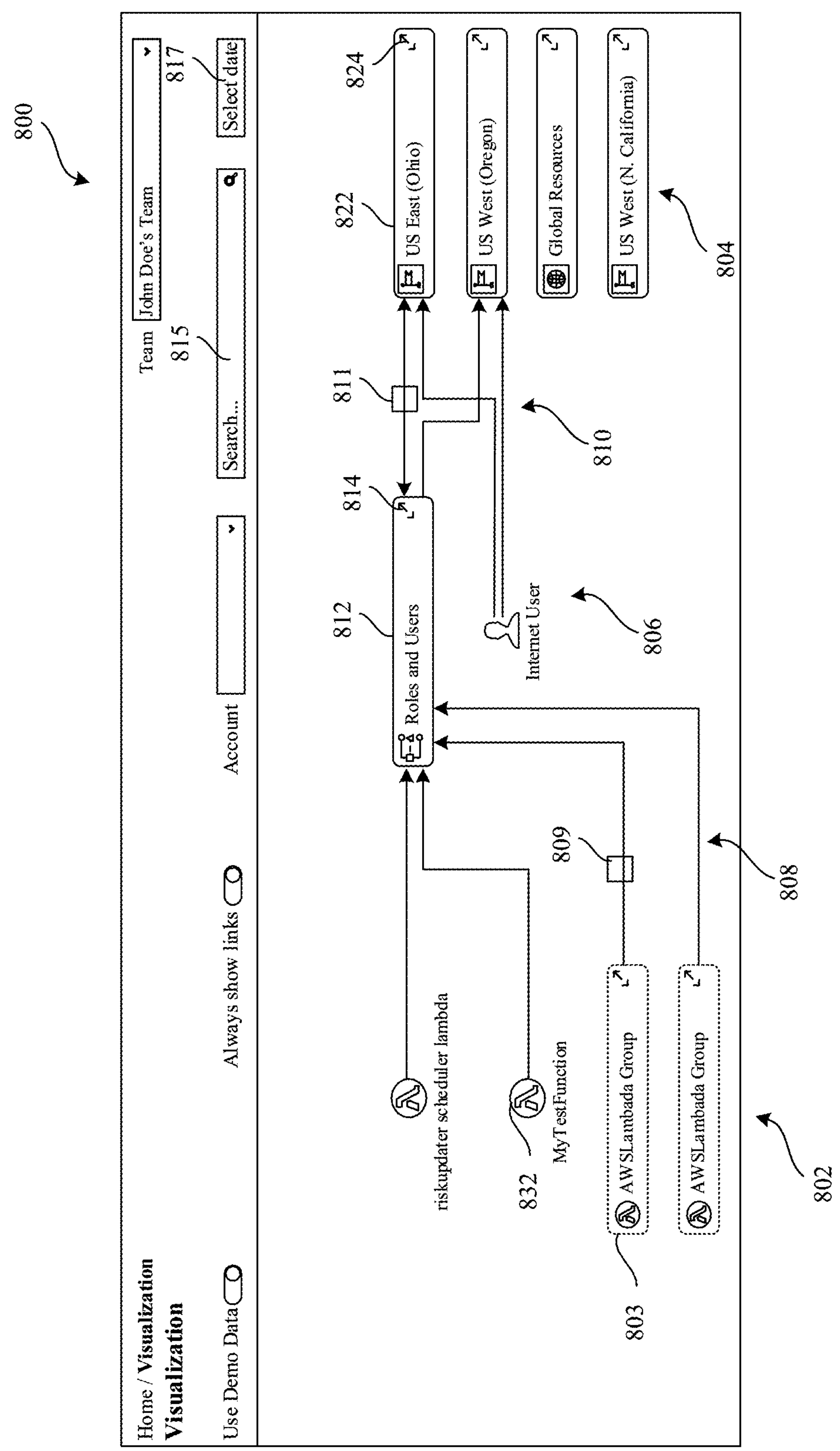
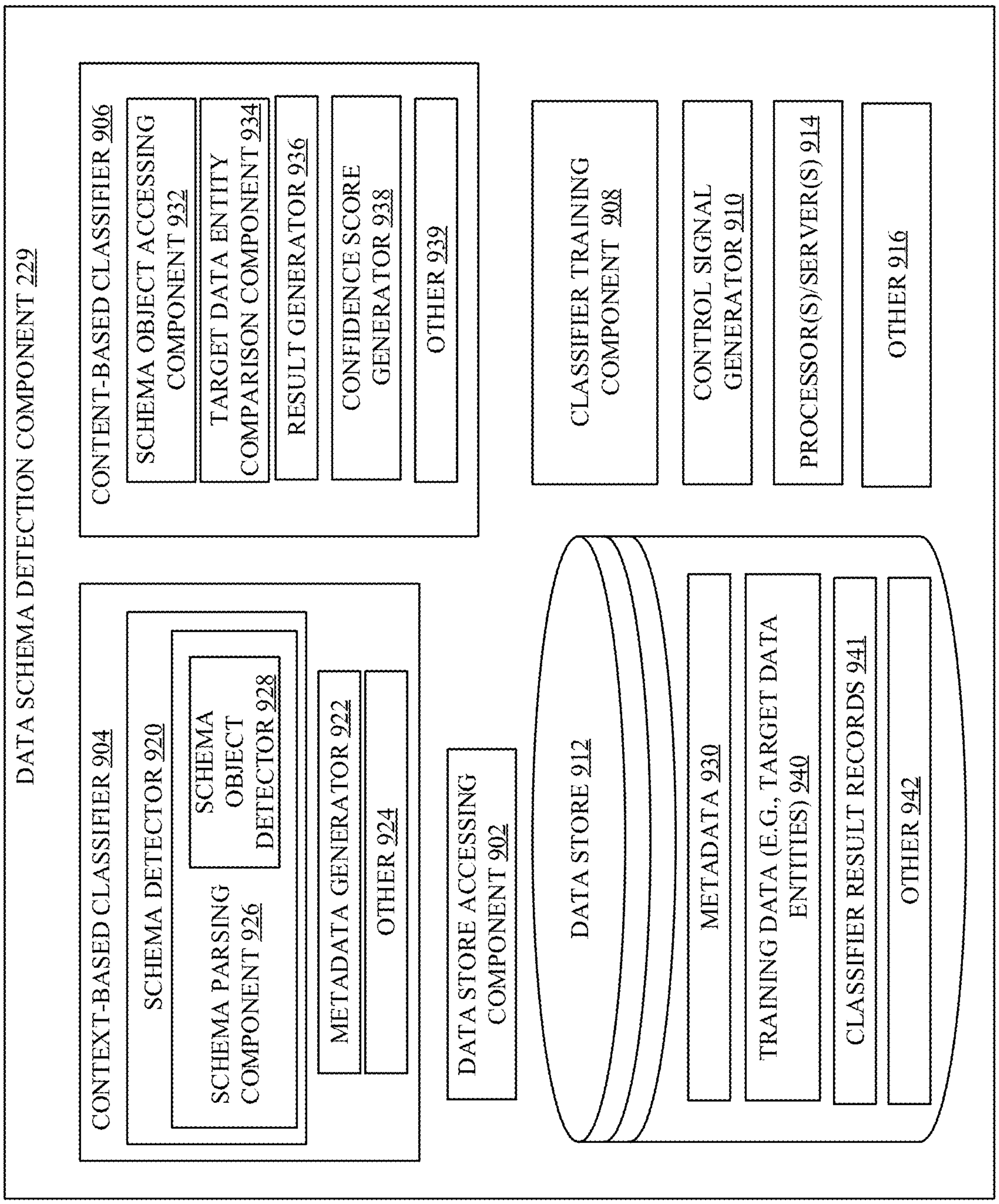
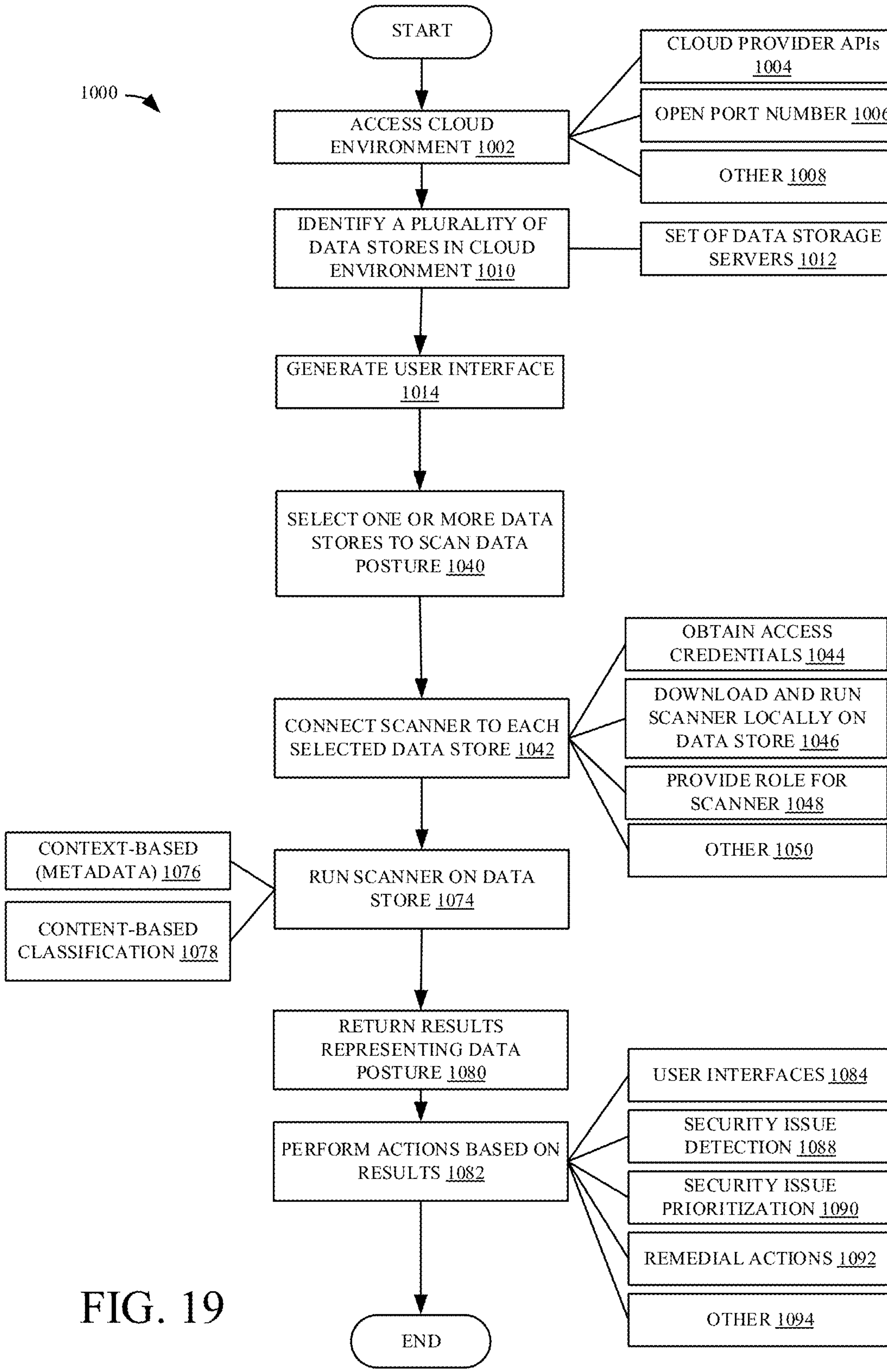

800
Home / Visualization
Visualization
Use Demo Data
Always show links
Account
Search...
815
Team
John Doe's Team
817
Select date
824
822
US East (Ohio)
US West (Oregon)
Global Resources
US West (N. California)
804
811
810
814
812
Roles and Users
Internet User
806
809
808
riskupdater scheduler lambda
MyTestFunction
832
AWSLambada Group
AWSLambada Group
803
802

FIG. 17

FIG. 18


DATA SCHEMA DETECTION COMPONENT 229
CONTEXT-BASED CLASSIFIER 904
SCHEMA DETECTOR 920
SCHEMA PARSING COMPONENT 926
SCHEMA OBJECT DETECTOR 928
METADATA GENERATOR 922
OTHER 924
CONTENT-BASED CLASSIFIER 906
SCHEMA OBJECT ACCESSING COMPONENT 932
TARGET DATA ENTITY COMPARISON COMPONENT 934
RESULT GENERATOR 936
CONFIDENCE SCORE GENERATOR 938
OTHER 939
DATA STORE ACCESSING COMPONENT 902
DATA STORE 912
METADATA 930
TRAINING DATA (E.G., TARGET DATA ENTITIES) 940
CLASSIFIER RESULT RECORDS 941
OTHER 942
CLASSIFIER TRAINING COMPONENT 908
CONTROL SIGNAL GENERATOR 910
PROCESSOR(S)/SERVER(S) 914
OTHER 916



1000
START
ACCESS CLOUD ENVIRONMENT 1002
CLOUD PROVIDER APIs 1004
OPEN PORT NUMBER 1006
OTHER 1008
IDENTIFY A PLURALITY OF DATA STORES IN CLOUD ENVIRONMENT 1010
SET OF DATA STORAGE SERVERS 1012
GENERATE USER INTERFACE 1014
SELECT ONE OR MORE DATA STORES TO SCAN DATA POSTURE 1040
CONNECT SCANNER TO EACH SELECTED DATA STORE 1042
OBTAIN ACCESS CREDENTIALS 1044
DOWNLOAD AND RUN SCANNER LOCALLY ON DATA STORE 1046
PROVIDE ROLE FOR SCANNER 1048
OTHER 1050
RUN SCANNER ON DATA STORE 1074
CONTEXT-BASED (METADATA) 1076
CONTENT-BASED CLASSIFICATION 1078
RETURN RESULTS REPRESENTING DATA POSTURE 1080
PERFORM ACTIONS BASED ON RESULTS 1082
USER INTERFACES 1084
SECURITY ISSUE DETECTION 1088
SECURITY ISSUE PRIORITIZATION 1090
REMEDIAL ACTIONS 1092
OTHER 1094
END

FIG. 19

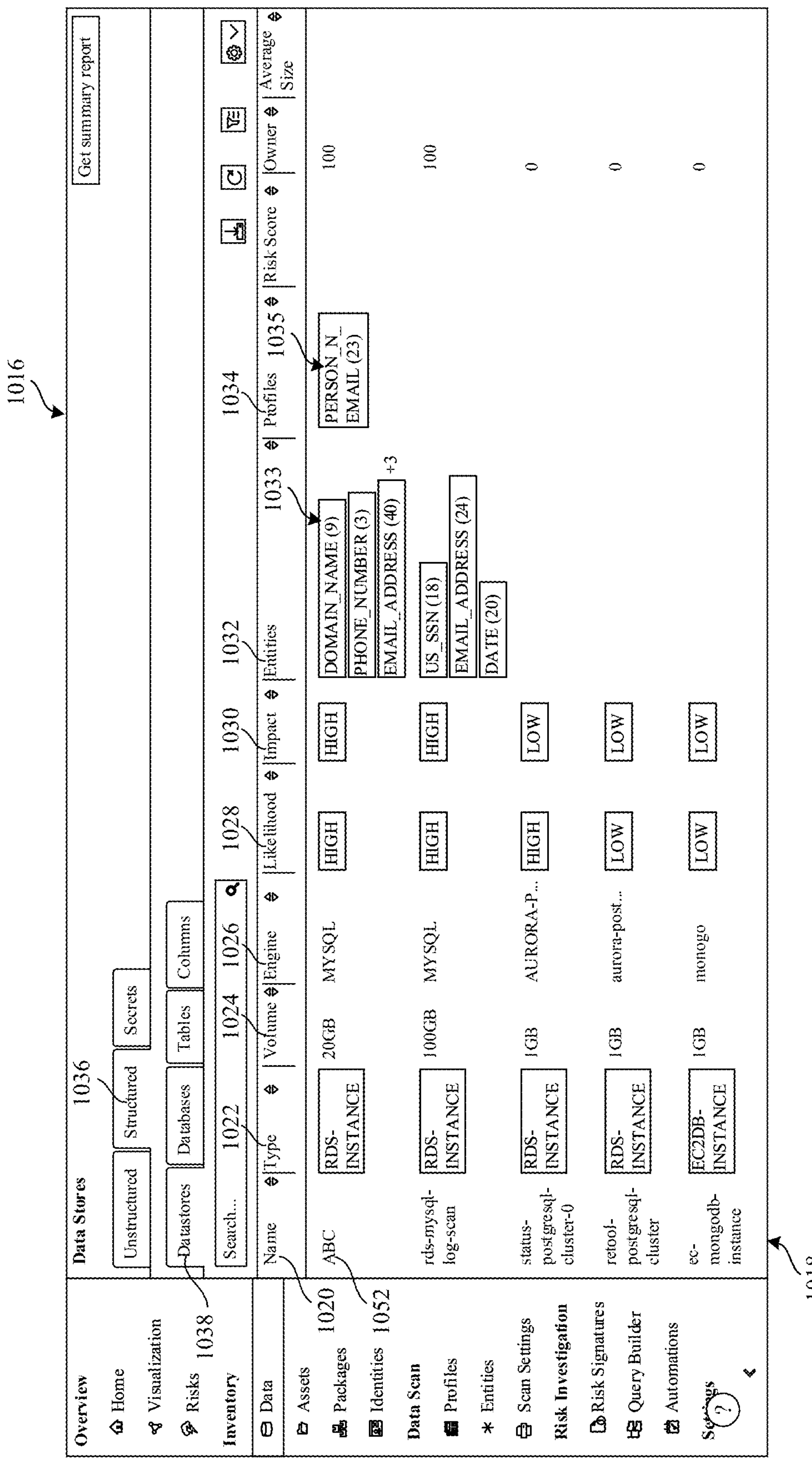
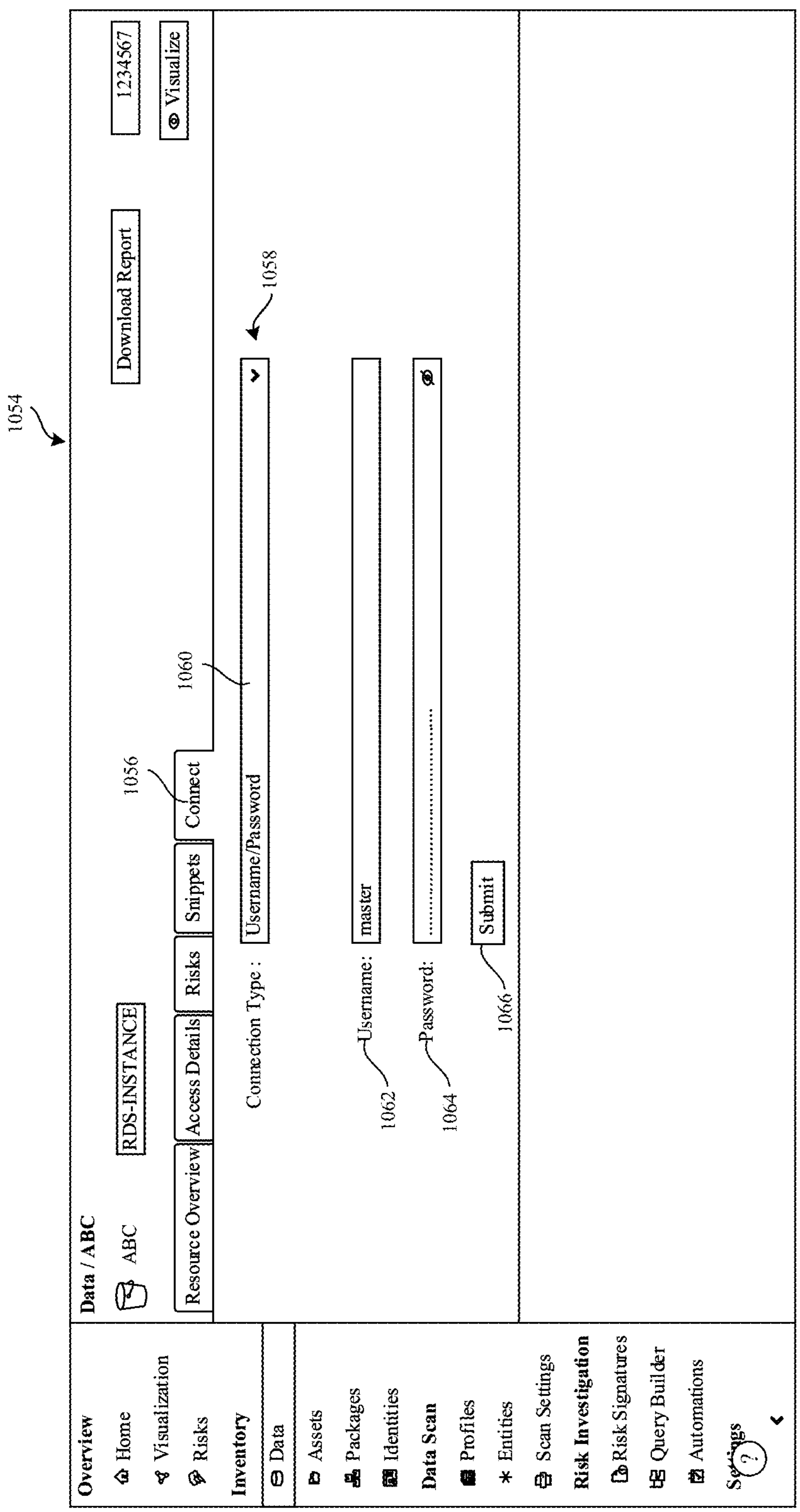

1016
Data Stores
Get summary report
Unstructured
Structured
Secrets
1036
Datastores
Databases
Tables
Columns
1038
Search...
1022
1024
1026
Name
Type
Volume
Engine
Likelihood
Impact
Entities
Profiles
Risk Score
Owner
Average Size
1020
1028
1030
1032
1033
1034
1035
ABC
1052
RDS-INSTANCE
20GB
MYSQL
HIGH
HIGH
DOMAIN_NAME (9)
PHONE_NUMBER (3)
EMAIL_ADDRESS (40)
+3
PERSON_N_EMAIL (23)
100
rds-mysql-log-scan
RDS-INSTANCE
100GB
MYSQL
HIGH
HIGH
US_SSN (18)
EMAIL_ADDRESS (24)
DATE (20)
100
status-postgresql-cluster-0
RDS-INSTANCE
1GB
AURORA-P...
HIGH
LOW
0
retool-postgresql-cluster
RDS-INSTANCE
1GB
aurora-post...
LOW
LOW
0
ec-mongodb-instance
EC2DB-INSTANCE
1GB
monogo
LOW
LOW
0
1018
Overview
Home
Visualization
Risks
Inventory
Data
Assets
Packages
Identities
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automations
Settings

FIG. 20



1054
Overview
Home
Visualization
Risks
Inventory
Data
Assets
Packages
Identities
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automations
Settings
Data / ABC
ABC
RDS-INSTANCE
Download Report
1234567
Visualize
Resource Overview
Access Details
Risks
Snippets
Connect
1056
1060
1058
Connection Type :
Username/Password
Username:
master
Password:
Submit
1062
1064
1066

FIG. 21

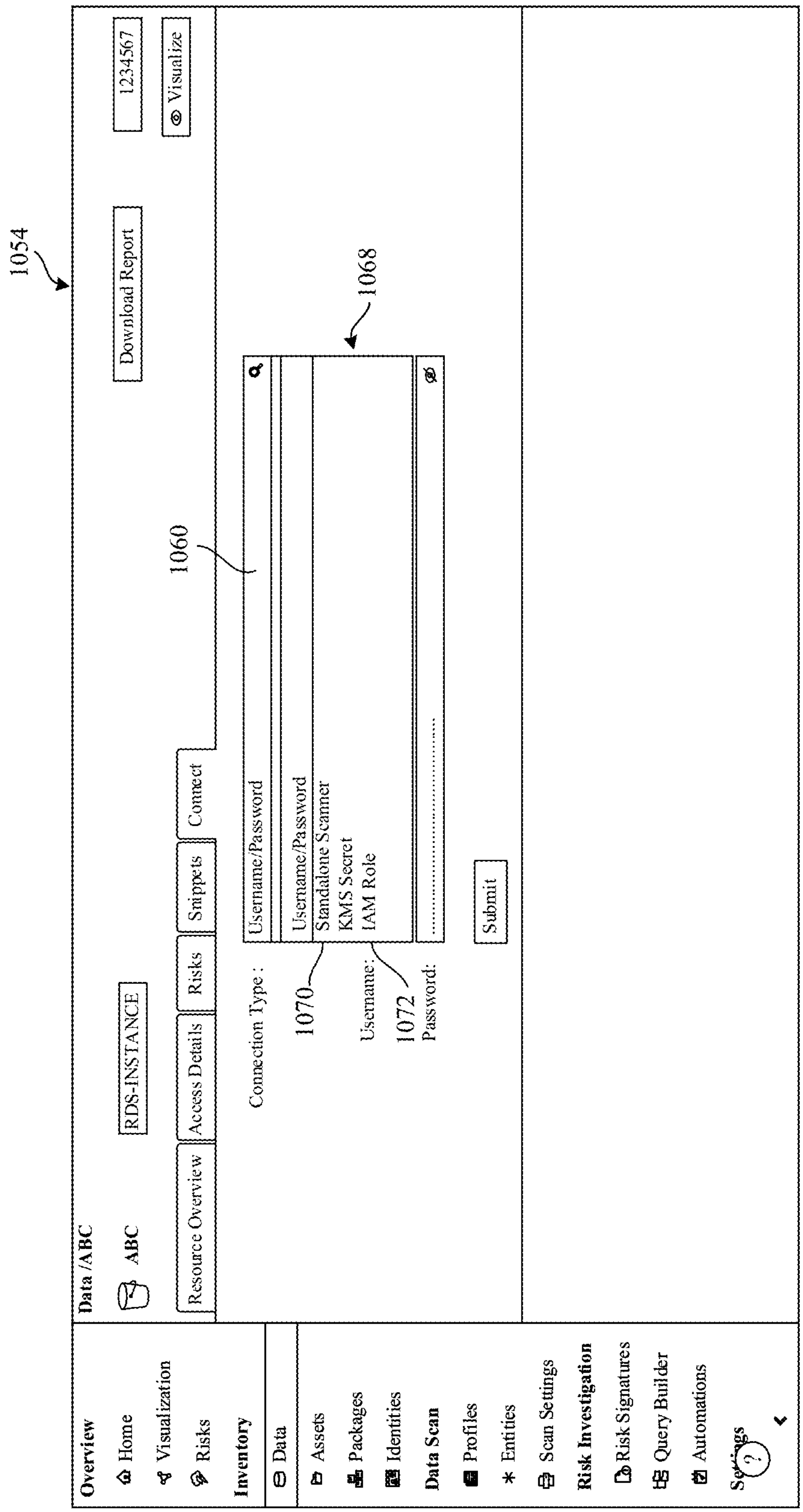

1054
Overview
Home
Visualization
Risks
Inventory
Data
Assets
Packages
Identities
Data Scan
Profiles
Entities
Scan Settings
Risk Investigation
Risk Signatures
Query Builder
Automations
Settings
Data /ABC
ABC
RDS-INSTANCE
Download Report
1234567
Visualize
Resource Overview
Access Details
Risks
Snippets
Connect
1060
1068
Connection Type :
Username/Password
Username/Password
Standalone Scanner
KMS Secret
IAM Role
1070
Username:
1072
Password:
Submit

FIG. 22

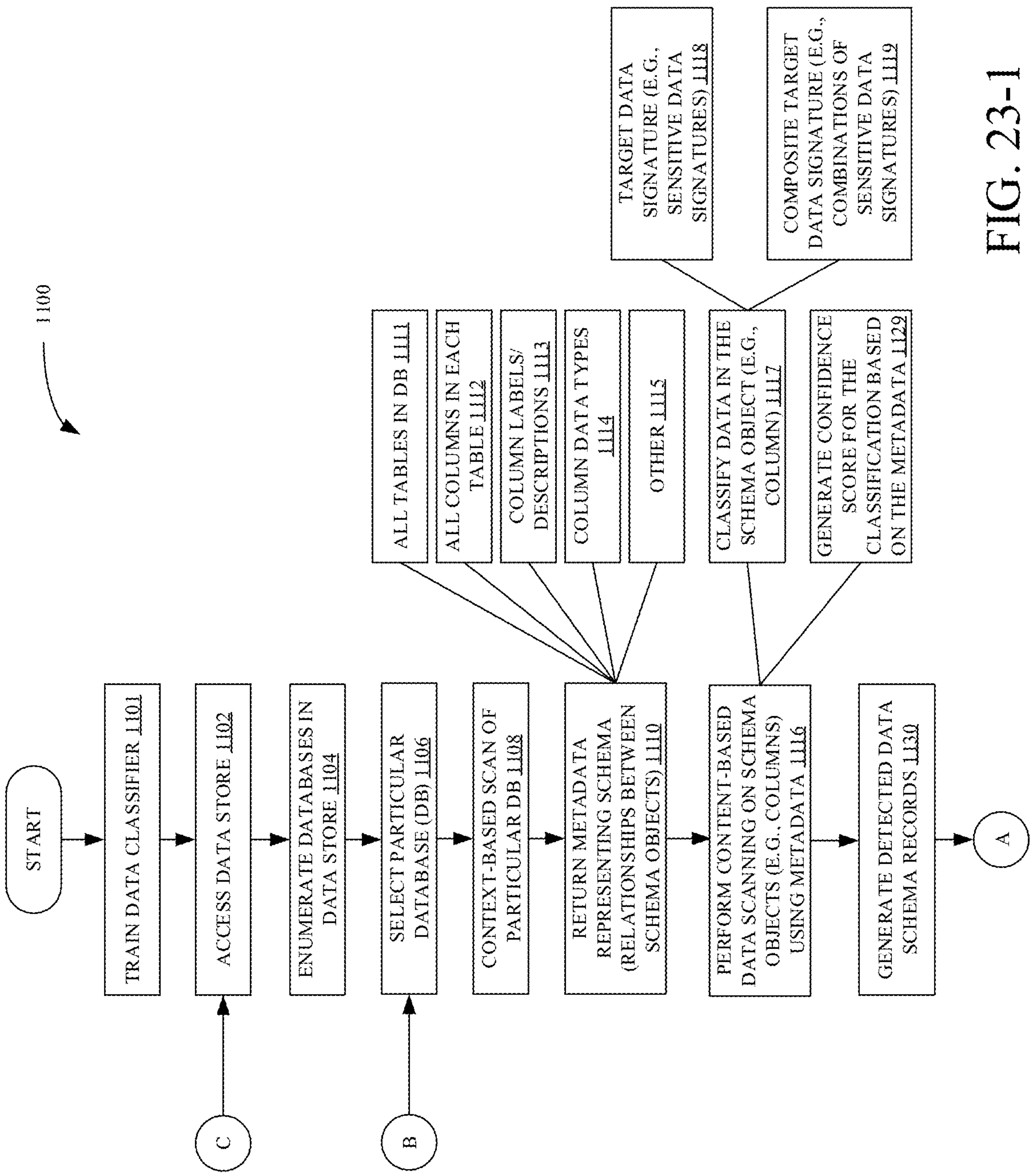

1100
START
TRAIN DATA CLASSIFIER 1101
ACCESS DATA STORE 1102
ENUMERATE DATABASES IN DATA STORE 1104
SELECT PARTICULAR DATABASE (DB) 1106
CONTEXT-BASED SCAN OF PARTICULAR DB 1108
RETURN METADATA REPRESENTING SCHEMA (RELATIONSHIPS BETWEEN SCHEMA OBJECTS) 1110
PERFORM CONTENT-BASED DATA SCANNING ON SCHEMA OBJECTS (E.G., COLUMNS) USING METADATA 1116
GENERATE DETECTED DATA SCHEMA RECORDS 1130
A
B
C
ALL TABLES IN DB 1111
ALL COLUMNS IN EACH TABLE 1112
COLUMN LABELS/ DESCRIPTIONS 1113
COLUMN DATA TYPES 1114
OTHER 1115
CLASSIFY DATA IN THE SCHEMA OBJECT (E.G., COLUMN) 1117
GENERATE CONFIDENCE SCORE FOR THE CLASSIFICATION BASED ON THE METADATA 1129
TARGET DATA SIGNATURE (E.G., SENSITIVE DATA SIGNATURES) 1118
COMPOSITE TARGET DATA SIGNATURE (E.G., COMBINATIONS OF SENSITIVE DATA SIGNATURES) 1119

FIG. 23-1

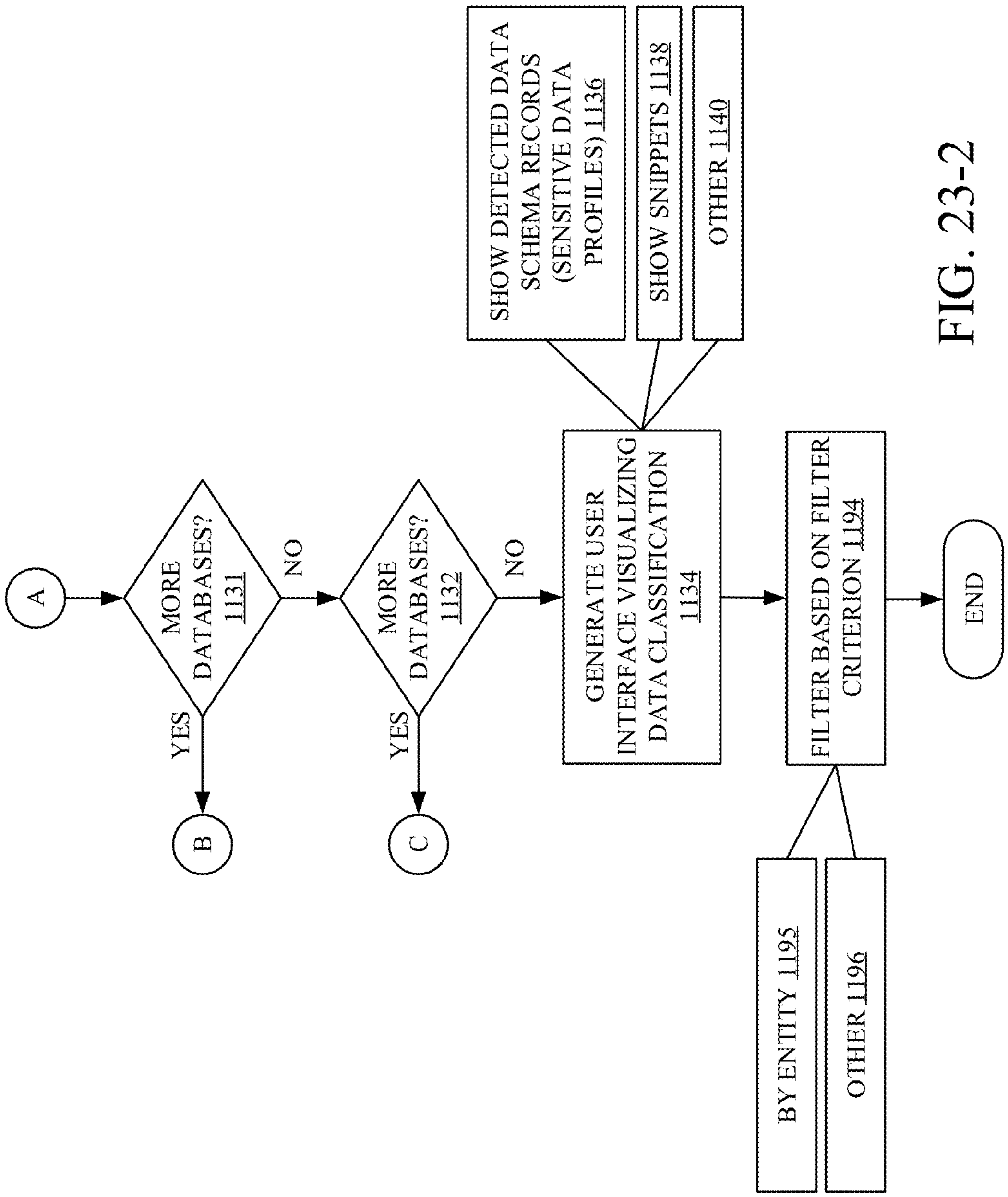

A
MORE DATABASES? 1131
YES
NO
B
MORE DATABASES? 1132
YES
NO
C
GENERATE USER INTERFACE VISUALIZING DATA CLASSIFICATION 1134
SHOW DETECTED DATA SCHEMA RECORDS (SENSITIVE DATA PROFILES) 1136
SHOW SNIPPETS 1138
OTHER 1140
FILTER BASED ON FILTER CRITERION 1194
BY ENTITY 1195
OTHER 1196
END

FIG. 23-2

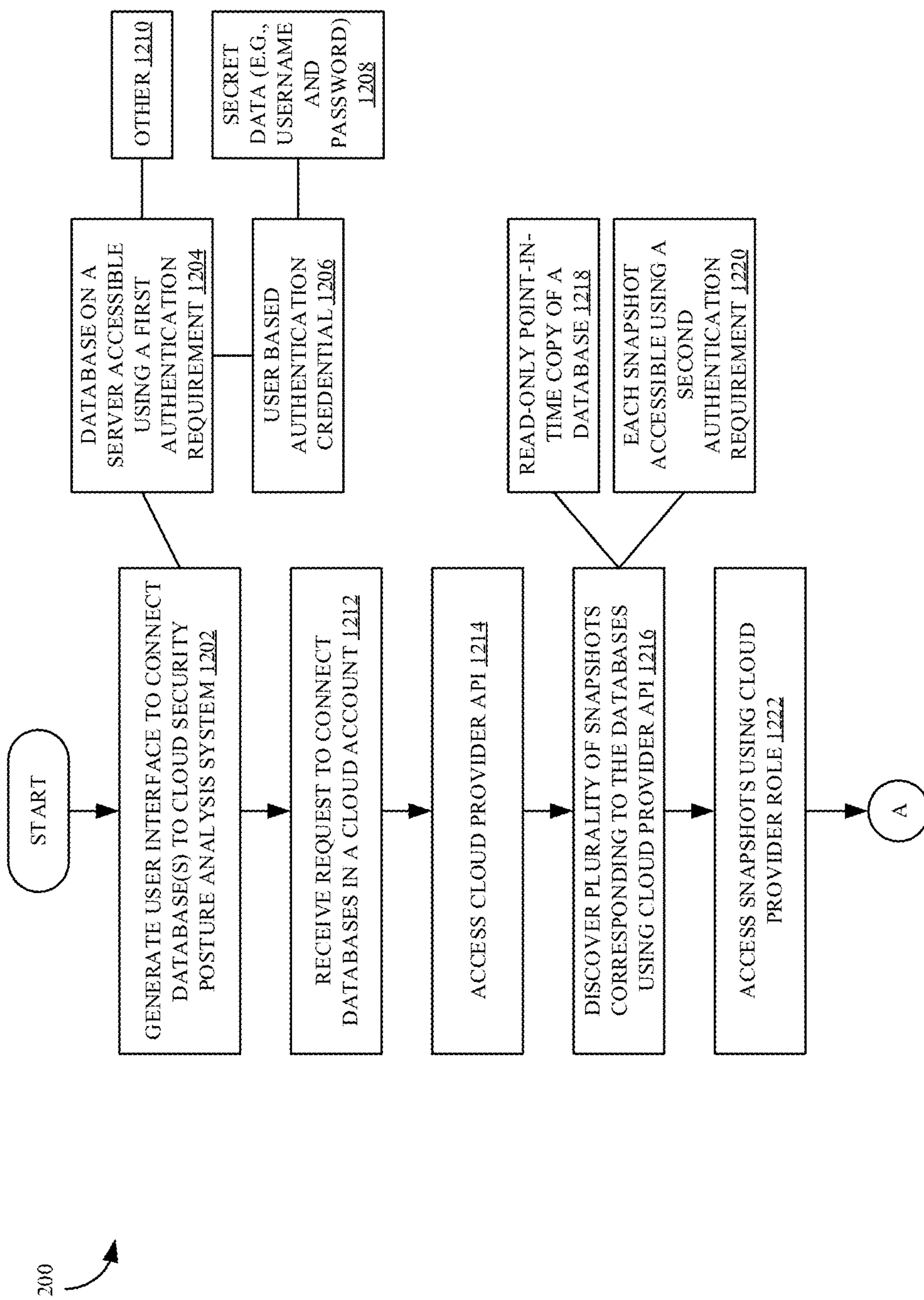

1200
START
GENERATE USER INTERFACE TO CONNECT DATABASE(S) TO CLOUD SECURITY POSTURE ANALYSIS SYSTEM 1202
DATABASE ON A SERVER ACCESSIBLE USING A FIRST AUTHENTICATION REQUIREMENT 1204
USER BASED AUTHENTICATION CREDENTIAL 1206
SECRET DATA (E.G., USERNAME AND PASSWORD) 1208
OTHER 1210
RECEIVE REQUEST TO CONNECT DATABASES IN A CLOUD ACCOUNT 1212
ACCESS CLOUD PROVIDER API 1214
DISCOVER PLURALITY OF SNAPSHOTS CORRESPONDING TO THE DATABASES USING CLOUD PROVIDER API 1216
READ-ONLY POINT-IN-TIME COPY OF A DATABASE 1218
EACH SNAPSHOT ACCESSIBLE USING A SECOND AUTHENTICATION REQUIREMENT 1220
ACCESS SNAPSHOTS USING CLOUD PROVIDER ROLE 1222
A

FIG. 24-1

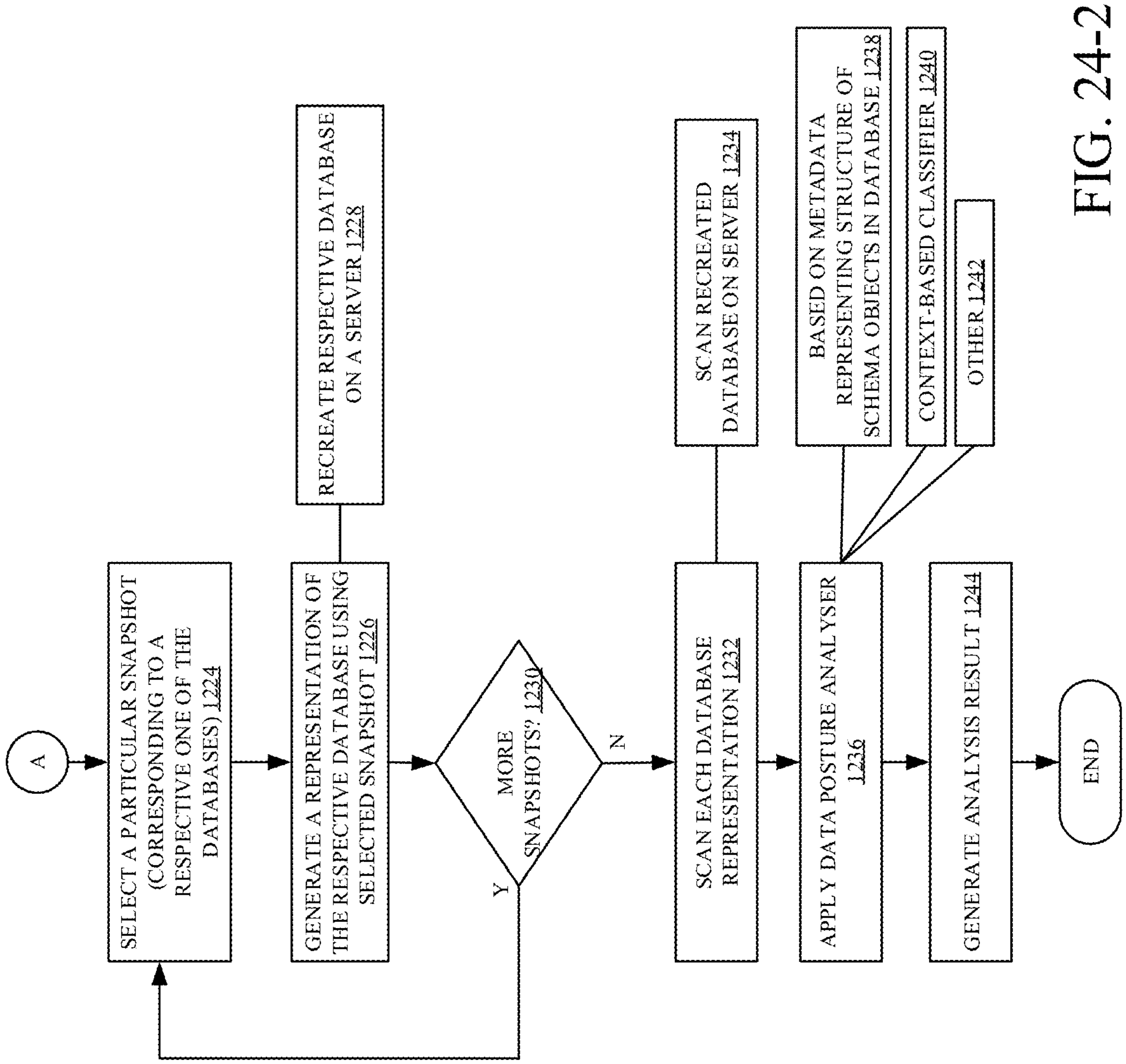

A
SELECT A PARTICULAR SNAPSHOT (CORRESPONDING TO A RESPECTIVE ONE OF THE DATABASES) 1224
GENERATE A REPRESENTATION OF THE RESPECTIVE DATABASE USING SELECTED SNAPSHOT 1226
RECREATE RESPECTIVE DATABASE ON A SERVER 1228
MORE SNAPSHOTS? 1230
Y
N
SCAN EACH DATABASE REPRESENTATION 1232
SCAN RECREATED DATABASE ON SERVER 1234
APPLY DATA POSTURE ANALYSER 1236
BASED ON METADATA REPRESENTING STRUCTURE OF SCHEMA OBJECTS IN DATABASE 1238
CONTEXT-BASED CLASSIFIER 1240
OTHER 1242
GENERATE ANALYSIS RESULT 1244
END

FIG. 24-2

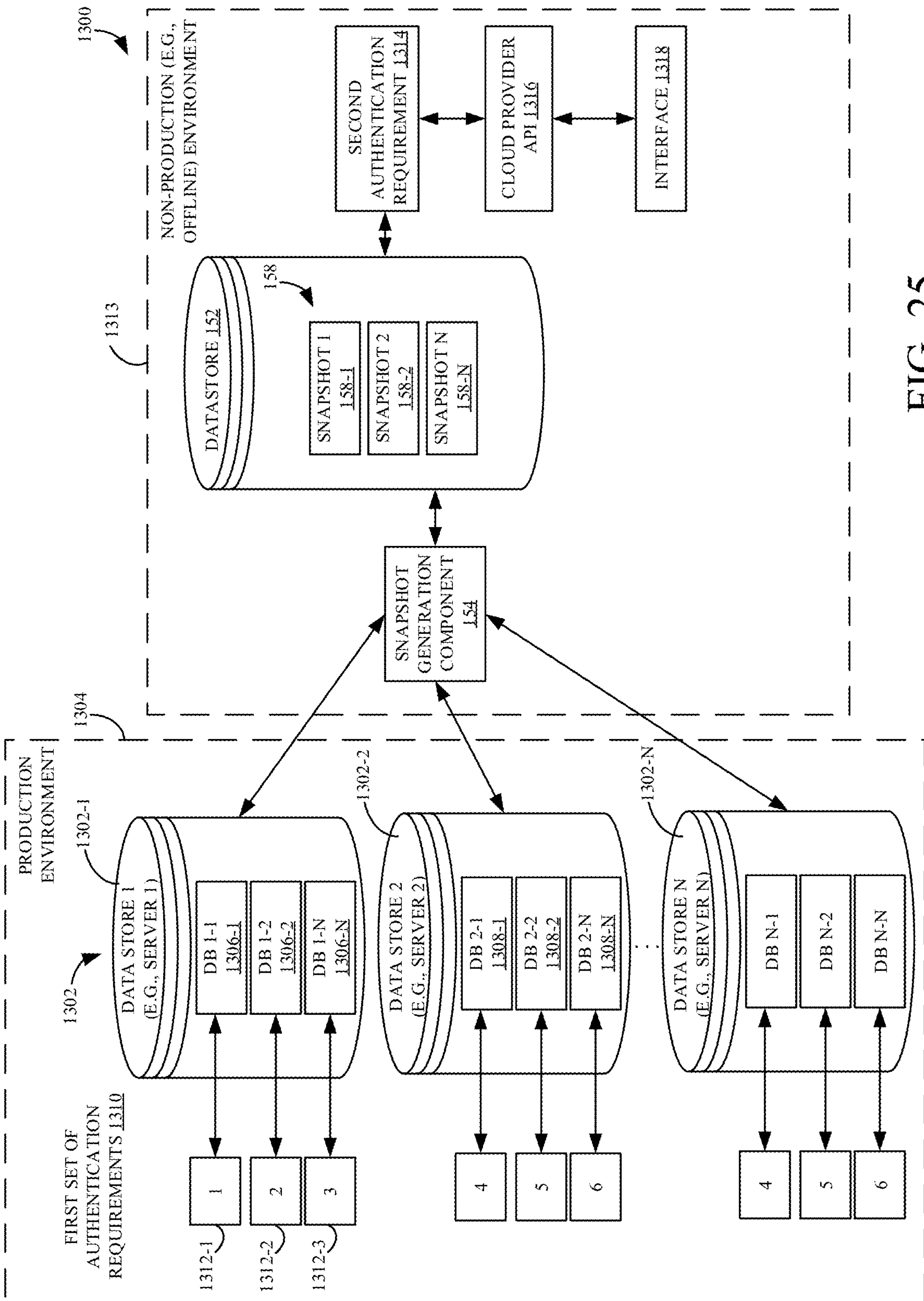

1300
NON-PRODUCTION (E.G., OFFLINE) ENVIRONMENT
1313
DATASTORE 152
158
SNAPSHOT 1 158-1
SNAPSHOT 2 158-2
SNAPSHOT N 158-N
SECOND AUTHENTICATION REQUIREMENT 1314
CLOUD PROVIDER API 1316
INTERFACE 1318
SNAPSHOT GENERATION COMPONENT 154
1304
PRODUCTION ENVIRONMENT
1302
1302-1
DATA STORE 1 (E.G., SERVER 1)
DB 1-1 1306-1
DB 1-2 1306-2
DB 1-N 1306-N
1302-2
DATA STORE 2 (E.G., SERVER 2)
DB 2-1 1308-1
DB 2-2 1308-2
DB 2-N 1308-N
1302-N
DATA STORE N (E.G., SERVER N)
DB N-1
DB N-2
DB N-N
FIRST SET OF AUTHENTICATION REQUIREMENTS 1310
1
2
3
4
5
6
4
5
6
1312-1
1312-2
1312-3

FIG. 25

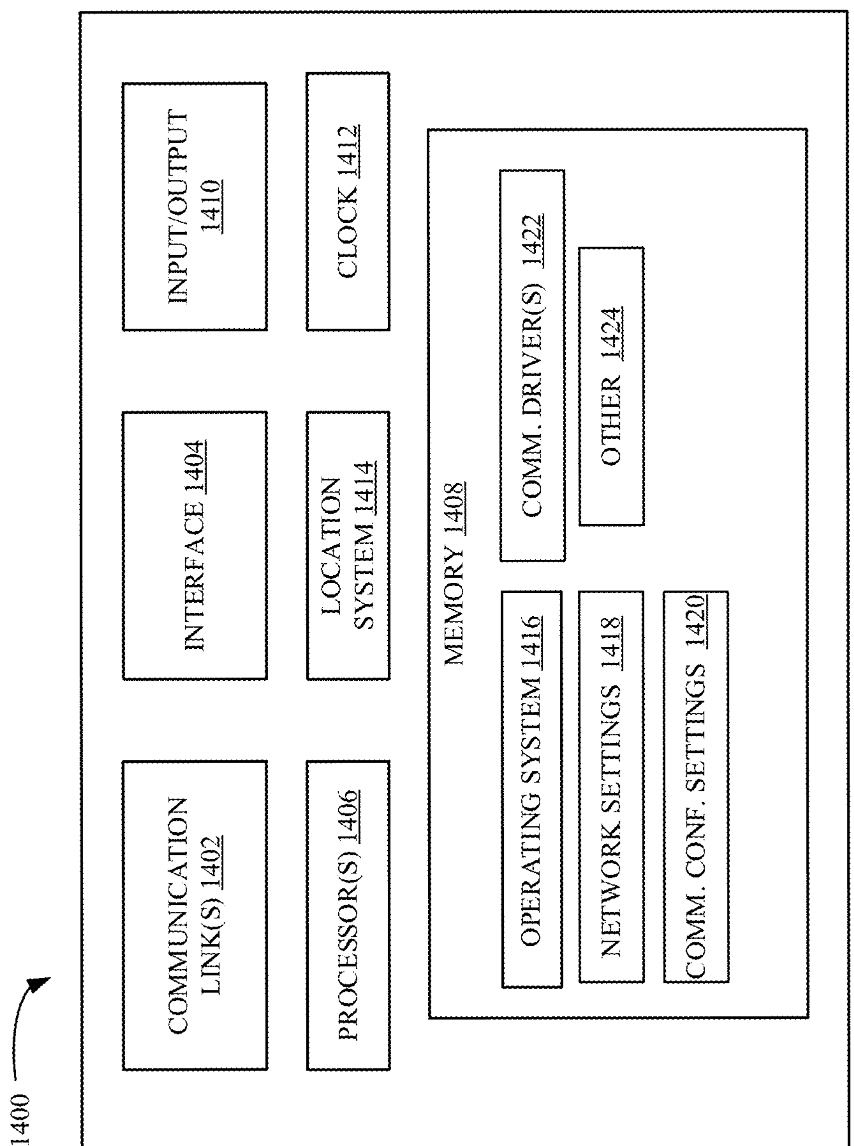

1400
COMMUNICATION LINK(S) 1402
INTERFACE 1404
INPUT/OUTPUT 1410
PROCESSOR(S) 1406
LOCATION SYSTEM 1414
CLOCK 1412
MEMORY 1408
OPERATING SYSTEM 1416
NETWORK SETTINGS 1418
COMM. CONF. SETTINGS 1420
COMM. DRIVER(S) 1422
OTHER 1424

FIG. 26

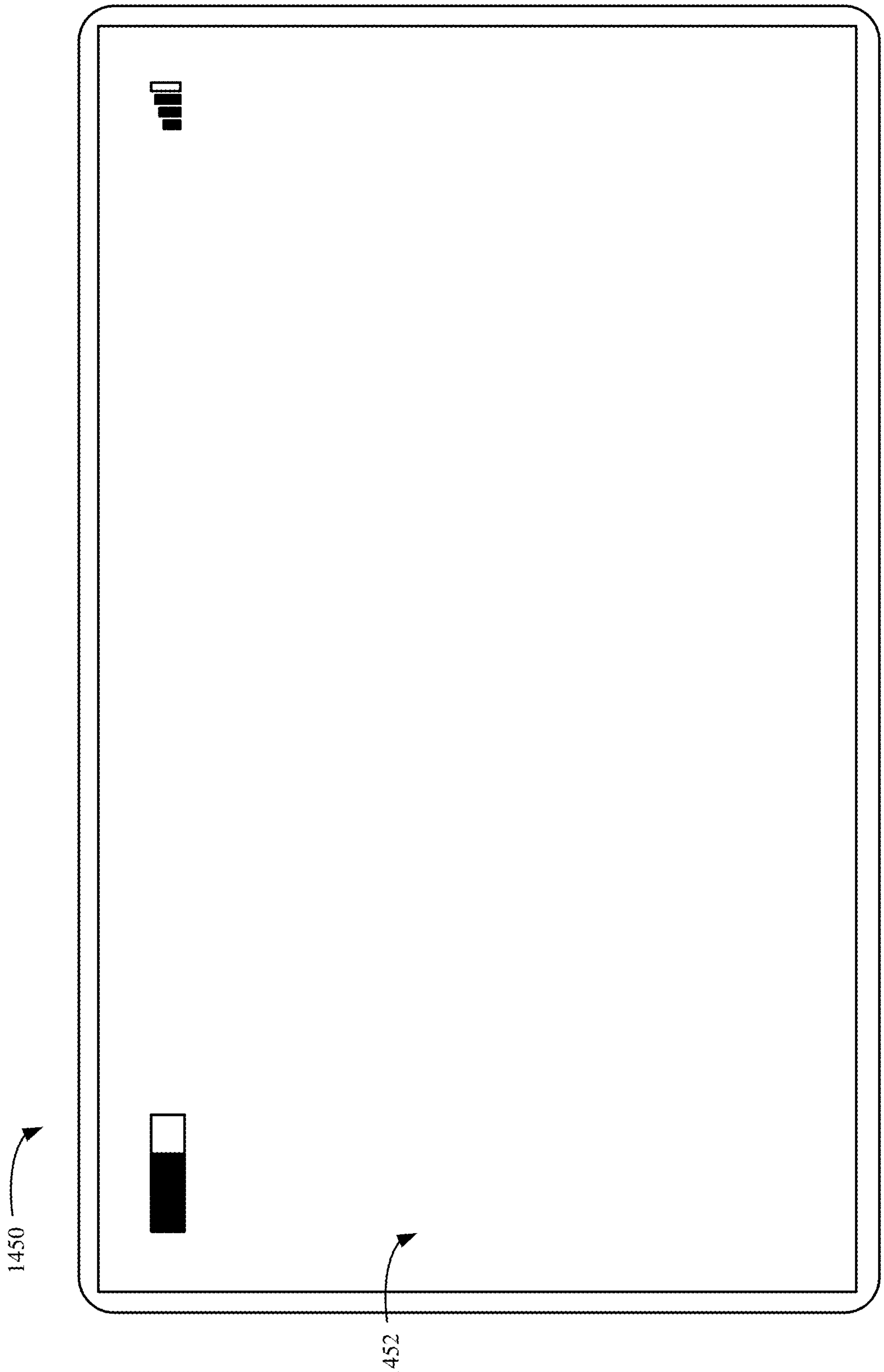


FIG. 27

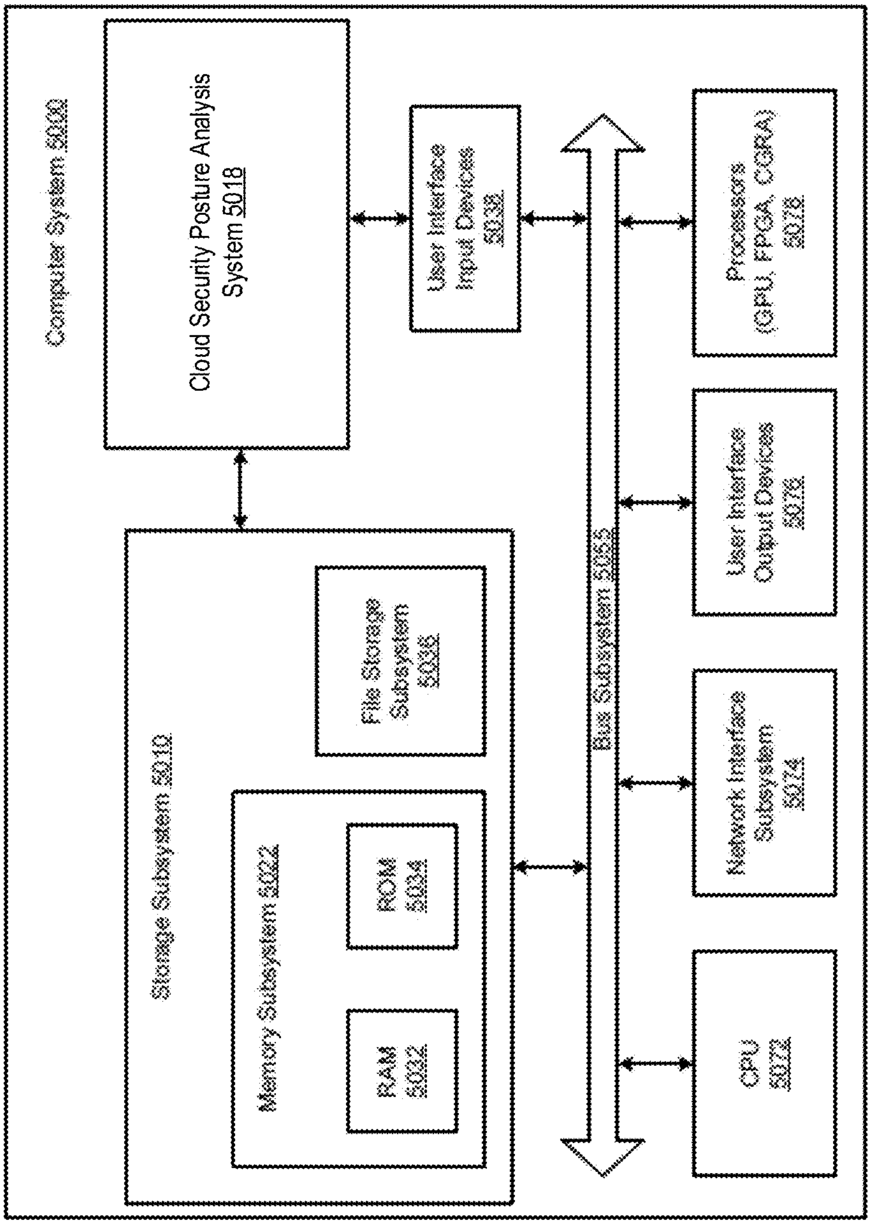

Computer System 5000
Cloud Security Posture Analysis System 5018
User Interface Input Devices 5038
Bus Subsystem 5055
Storage Subsystem 5010
Memory Subsystem 5022
RAM 5032
ROM 5034
File Storage Subsystem 5036
Processors (GPU, FPGA, CGRA) 5078
User Interface Output Devices 5076
Network Interface Subsystem 5074
CPU 5072

FIG. 28

DATA POSTURE ANALYSIS IN A CLOUD ENVIRONMENT USING DATABASE SNAPSHOTS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 17/939,501, filed Sep. 7, 2022, which claims the benefit of U.S. provisional patent application Ser. No. 63/246,303, filed Sep. 20, 2021, 63/246,310, filed Sep. 21, 2021, 63/246,313, filed Sep. 21, 2021, and 63/246,315, filed Sep. 21, 2021; the contents of these applications are hereby incorporated by reference in their entirety. The present application is also related to U.S. patent application Ser. No. 17/858,903, filed Jul. 6, 2022, Ser. No. 17/858,907, filed Jul. 6, 2022, Ser. No. 17/858,914, filed Jul. 6, 2022, and Ser. No. 17/858,919, filed Jul. 6, 2022; the contents of these applications are hereby incorporated by reference in their entirety.

FIELD OF THE TECHNOLOGY DISCLOSED

The technology disclosed generally relates to cloud environments. More specifically, but not by limitation, the present disclosure relates to improved systems and methods of cloud security posture management (CSPM), cloud infrastructure entitlement management (CIEM), cloud-native application protection platform (CNAPP), and/or cloud-native configuration management database (CMDB).

BACKGROUND

The subject matter discussed in this section should not be assumed to be prior art merely as a result of its mention in this section. Similarly, a problem mentioned in this section or associated with the subject matter provided as background should not be assumed to have been previously recognized in the prior art. The subject matter in this section merely represents different approaches, which in and of themselves can also correspond to implementations of the claimed technology.

Cloud computing provides on-demand availability of computer resources, such as data storage and compute resources, often without direct active management by users. Thus, a cloud environment can provide computation, software, data access, and storage services that do not require end-user knowledge of the physical location or configuration of the system that delivers the services. In various examples, remote servers can deliver the services over a wide area network, such as the Internet, using appropriate protocols, and those services can be accessed through a web browser or any other computing component.

Examples of cloud storage services include Amazon Web Services' (AWS), Google Cloud Platform™ (GCP), and Microsoft Azure™, to name a few. Such cloud storage services provide on-demand network access to a shared pool of configurable resources. These resources can include networks, servers, storage, applications, services, etc. The end-users of such cloud services often include organizations that have a need to store sensitive and/or confidential data, such as personal information, financial information, medical information. Such information can be accessed by any of a number of users through permissions and access control data assigned or otherwise defined through administrator accounts.

The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter.

SUMMARY

The technology disclosed relates to streamlined analysis of security posture of a cloud environment. In particular, the disclosed technology relates to a system that analyzes data posture in a cloud environment database using a snapshot of the database. A computer-implemented method includes receiving a request to access a database in the cloud environment, wherein the database includes a first authentication requirement. The method includes identifying a snapshot of the database, wherein the snapshot includes a second authentication requirement that is different than the first authentication requirement. The method includes accessing the snapshot using the second authentication requirement, generating a representation of the database using the snapshot, and generating a data posture analysis result indicative of a data posture of the database based on scanning the representation of the database.

Example 1 is a computer-implemented method for analyzing data posture in a cloud environment, the method comprising:

- receiving a request to access a database in the cloud environment, wherein the database includes a first authentication requirement;
- identifying a snapshot of the database, wherein the snapshot includes a second authentication requirement that is different than the first authentication requirement;
- accessing the snapshot using the second authentication requirement;
- generating a representation of the database using the snapshot; and generating a data posture analysis result indicative of a data posture of the database based on scanning the representation of the database.

Example 2 is the computer-implemented method of any or all previous examples, wherein the first authentication requirement comprises a user access credential, and the second authentication requirement comprises a cloud environment role.

Example 3 is the computer-implemented method of any or all previous examples, wherein the user access credential comprises secret data corresponding to a user associated with the database, and wherein the cloud environment role comprises a cloud provider role.

Example 4 is the computer-implemented method of any or all previous examples, wherein the database comprises a first database having a first user access credential, and wherein the snapshot comprises a first snapshot, and further comprising:

- receiving a request to access a second database in the cloud environment, wherein the second database includes a second user access credential that is different than the first user access credential; and
- identifying a second snapshot of the second database, wherein the second snapshot includes a same authentication requirement as the first snapshot.

Example 5 is the computer-implemented method of any or all previous examples, and further comprising:

- discovering the first and second snapshots using a cloud provider application programming interface (API); and
- accessing each of the first and second snapshots through the cloud provider API.

Example 6 is the computer-implemented method of any or all previous examples, wherein generating the data posture analysis result comprises:

obtaining metadata representing a structure of schema objects in the database; and

based on the metadata, executing a content-based data classifier to classify data items in the schema objects.

Example 7 is the computer-implemented method of any or all previous examples, wherein

the database is stored on a first server in the cloud environment,

generating the representation of the database comprises recreating the database on a second server using the snapshot, and scanning the representation of the database comprises scanning the recreated database on the second server.

Example 8 is the computer-implemented method of any or all previous examples, wherein the snapshot comprises a read-only point-in-time copy of the database.

Example 9 is the computer-implemented method of any or all previous examples, wherein the database is deployed in a production environment and configured to receive a user request for a data manipulation operation on data stored in the database.

Example 10 is a computing system comprising

at least one processor; and

memory storing instructions executable by the at least one processor, wherein the instructions, when executed, cause the computing system to:

receive a request to access a database in a cloud environment, wherein the database includes a user-based authentication credential;

identify a point-in-time copy of the database that includes a role-based authentication credential;

access the point-in-time copy using the role-based authentication credential;

generate a representation of the database using the point-in-time copy; and

generate a data posture analysis result indicative of a data posture of the database based on scanning the representation of the database.

Example 11 is the computing system of any or all previous examples, wherein the user-based authentication credential comprises a user access credential, and the role-based authentication credential comprises a cloud provider role.

Example 12 is the computing system of any or all previous examples, wherein the user access credential comprises secret data corresponding to a user associated with the database.

Example 13 is the computing system of any or all previous examples, wherein the database comprises a first database having a first user access credential, and wherein the point-in-time copy comprises a first point-in-time copy, and wherein the instructions, when executed, cause the computing system to:

receive a request to access a second database in the cloud environment, wherein the second database includes a second user access credential that is different than the first user access credential; and

identify a second point-in-time copy of the second database, wherein the second point-in-time copy includes a same authentication requirement as the first point-in-time copy.

Example 14 is the computing system of any or all previous examples, wherein the instructions, when executed, cause the computing system to:

discover the first and second point-in-time copies using a cloud provider application programing interface (API); and

access each of the first and second point-in-time copies through the cloud provider API using the same authentication requirement.

Example 15 is the computing system of any or all previous examples, wherein the instructions, when executed, cause the computing system to:

obtain metadata representing a structure of schema objects in the database; and

based on the metadata, execute a content-based data classifier to classify data items in the schema objects.

Example 16 is the computing system of any or all previous examples, wherein the database is deployed in a production environment and configured to receive a user request for a data manipulation operation on data stored in the database.

Example 17 is a computing system comprising:

at least one processor; and

memory storing instructions executable by the at least one processor, wherein the instructions, when executed, cause the computing system to:

receive one or more requests to access a plurality of databases in the cloud environment, wherein the plurality of databases includes different sets of authentication requirements;

identify a plurality of snapshots that correspond to the plurality of databases, wherein the plurality of snapshots includes a same authentication requirement;

access each snapshot of the plurality of snapshots using the same authentication requirement;

generate a set of representations of the plurality of databases using the plurality of snapshots; and

generate a data posture analysis result indicative of a data posture of the plurality of databases based on scanning the set of representations.

Example 18 is the computing system of any or all previous examples, wherein a first database of the plurality of databases has a first user access credential, and a second database of the plurality of databases has a second user access credential.

Example 19 is the computing system of any or all previous examples, wherein each particular snapshot of the plurality of snapshots comprises a read-only point-in-time copy of the database corresponding to the particular snapshot.

Example 20 is the computing system of any or all previous examples, wherein the database is stored on a first server in the cloud environment, and the instructions, when executed, cause the computing system to:

recreate each particular database, of the plurality of databases, in a cloud environment server using the snapshot corresponding to the particular database, and

scan the recreated databases to identify the data posture.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in the background.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters generally refer to like parts throughout the different views. Also, the drawings are not necessarily to scale, with an emphasis instead generally being placed upon illustrating the principles of the technology disclosed. In the following description, various implementations of the technology disclosed are described with reference to the following drawings, in which:

FIG. **1** is a block diagram illustrating one example of a cloud architecture.

FIG. **2** is a block diagram illustrating one example of a cloud service.

FIG. **3** is a block diagram illustrating one example of a cloud security posture analysis system.

FIG. **4** is a block diagram illustrating one example of a deployed scanner.

FIG. **5** is a flow diagram showing an example operation of on-boarding a cloud account and deploying one or more scanners.

FIG. **6** illustrates one example of a user interface display representing on-boarded cloud accounts.

FIG. **7** illustrates one example of an on-boarding user interface display.

FIG. **8** illustrates one example of a user interface display having a dashboard representing on-boarded cloud service accounts.

FIG. **9** is a flow diagram illustrating one example of cloud infrastructure scanning performed by a cloud scanner deployed in a cloud service.

FIGS. **10-1**, **10-2**, **10-3**, and **10-4** (collectively referred to as FIG. **10**) provide a flow diagram illustrating an example operation for streamlined analysis of security posture.

FIG. **11** illustrates one example of a user interface display that facilitates user definition of a risk criterion.

FIG. **12** illustrates one example of a user interface display that displays a set of risk signatures.

FIG. **13** illustrates one example of a user interface display that graphically depicts vulnerability risks.

FIG. **14** illustrates one example of a details display pane.

FIG. **15** illustrates one example of a user interface display that graphically depicts breach likelihood and impact scores.

FIG. **16** illustrates one example of a user interface display having a details pane that displays details for a given resource.

FIG. **17** illustrates a user interface display that includes a visualization of access communication paths.

FIG. **18** is a block diagram illustrating one example of a data schema detection component.

FIG. **19** is a flow diagram illustrating one example of scanning data stores in a cloud environment.

FIG. **20** illustrates an example user interface display that displays identified data stores.

FIG. **21** illustrates an example user interface display for connecting a data store.

FIG. **22** illustrates an example user interface display for selecting a connection type for connecting a data store.

FIGS. **23-1** and **23-2** (collectively referred to as FIG. **23**) provide a flow diagram illustrating one example of performing content-based classification of data items.

FIGS. **24-1** and **24-2** (collectively referred to as FIG. **24**) provide a flow diagram of an example operation of a cloud data schema detection system that performs data posture analytics using snapshotting.

FIG. **25** illustrates one example of a cloud environment having a plurality of data stores in a production environment.

FIG. **26** is a simplified block diagram of one example of a client device.

FIG. **27** illustrates an example of a handheld or mobile device.

FIG. **28** shows an example computer system.

DETAILED DESCRIPTION

The following discussion is presented to enable any person skilled in the art to make and use the technology disclosed, and is provided in the context of a particular application and its requirements. Various modifications to the disclosed implementations will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other implementations and applications without departing from the spirit and scope of the technology disclosed. Thus, the technology disclosed is not intended to be limited to the implementations shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

As noted above, cloud computing environments are used by organizations or other end-users to store a wide variety of different types of information in many contexts and for many uses. This data can often include sensitive and/or confidential information, and can be the target for malicious activity such as acts of fraud, privacy breaches, data theft, etc. These risks can arise from individuals that are both inside the organization as well as outside the organization.

Cloud environments often include security infrastructure to enforce access control, data loss prevention, or other processes to secure data from potential vulnerabilities. However, even with such security infrastructures, it can be difficult for an organization to understand the data posture and breadth of access to the data stored in the cloud in the organization's cloud account. In other words, it can be difficult to identify which users have access to which data, and which data may be exposed to malicious or otherwise unauthorized users, both inside or outside the organization.

The present system is directed to a cloud security posture analysis system configured to analyze and take action on the security posture of a cloud account. The system can discover sensitive data among the cloud storage resources and discover access patterns to the sensitive data. The results can be used to identify security vulnerabilities to understand the data security posture, detect and remediate the security vulnerabilities, and to prevent future breaches to sensitive data. The system provides real-time visibility and control on the control data infrastructure by discovering resources, sensitive data, and access paths, and tracking resource configuration, deep context and trust relationships in real-time as a graph or other visualization. It is noted that the technology disclosed herein can depict all graph embodiments in equivalent and analogous tabular formats or other visualization formats based on the data and logic disclosed herein.

The system can further score breach paths based on sensitivity, volume, and/or permissions to show an attack surface and perform constant time scanning, by deploying scanners locally within the cloud account. Thus, the scanners execute in the cloud service itself, with metadata being returned indicative of the analysis. Thus, in one example, an organization's cloud data does not leave the organization's cloud account. Rather, the data can be scanned in place and metadata sent for analysis by the cloud security posture analysis system, which further enhances data security.

FIG. **1** is a block diagram illustrating one example of a cloud architecture **100** in which a cloud environment **102** is accessed by one or more actors **104** through a network **106**, such as the Internet or other wide area network. Cloud environment **102** includes one or more cloud services **108-1**, **108-2**, **108**-N, collectively referred to as cloud services **108**.

As noted above, cloud services **108** can include cloud storage services such as, but not limited to, AWS, GCP, Microsoft Azure, to name a few.

Further, cloud services **108-1**, **108-2**, **108**-N can include the same type of cloud service, or can be different types of cloud services, and can be accessed by any of a number of different actors **104**. For example, as illustrated in FIG. **1**, actors **104** include users **110**, administrators **112**, developers **114**, organizations **116**, and/or applications **118**. Of course, other actors **120** can access cloud environment **102** as well.

Architecture **100** includes a cloud security posture analysis system **122** configured to access cloud services **108** to identify and analyze cloud security posture data. Examples of system **122** are discussed in further detail below. Briefly, however, system **122** is configured to access cloud services **108** and identify connected resources, entities, actors, etc. within those cloud services, and to identify risks and violations against access to sensitive information. As shown in FIG. **1**, system **122** can reside within cloud environment **102** or outside cloud environment **102**, as represented by the dashed box in FIG. **1**. Of course, system **122** can be distributed across multiple items inside and/or outside cloud environment **102**.

Users **110**, administrators **112**, developers **114**, or any other actors **104**, can interact with cloud environment **102** through user interface displays **123** having user interface mechanisms **124**. For example, a user can interact with user interface displays **123** provided on a user device (such as a mobile device, a laptop computer, a desktop computer, etc.) either directly or over network **106**. Cloud environment **102** can include other items **125** as well.

FIG. **2** is a block diagram illustrating one example of cloud service **108-1**. For the sake of the present discussion, but not by limitation, cloud service **108-1** will be discussed in the context of an account within AWS. Of course, other types of cloud services and providers are within the scope of the present disclosure.

Cloud service **108-1** includes a plurality of resources **126** and an access management and control system **128** configured to manage and control access to resources **126** by actors **104**. Resources **126** include compute resources **130**, storage resources **132**, and can include other resources **134**. Compute resources **130** include a plurality of individual compute resources **130-1**, **130-2**, **130**-N, which can be the same and/or different types of compute resources. In the present example, compute resources **130** can include elastic compute resources, such as elastic compute cloud (AWS EC2) resources, AWS Lambda, etc.

An elastic compute cloud (EC2) is a cloud computing service designed to provide virtual machines called instances, where users can select an instance with a desired amount of computing resources, such as the number and type of CPUs, memory and local storage. An EC2 resource allows users to create and run compute instances on AWS, and can use familiar operating systems like Linux, Windows, etc. Users can select an instance type based on the memory and computing requirements needed for the application or software to be run on the instance.

AWS Lambda is an event-based service that delivers short-term compute capabilities and is designed to run code without the need to deploy, use or manage virtual machine instances. An example implementation is used by an organization to address specific triggers or events, such as database updates, storage changes or custom events generated from other applications. Such a compute resource can include a server-less, event-driven compute service that allows a user to run code for many different types of applications or backend services without provisioning or managing servers.

Storage resources **132** are accessible through compute resources **130**, and can include a plurality of storage resources **132-1**, **132-2**, **132**-N, which can be the same and/or different types of storage resources. A storage resource **132** can be defined based on object storage. For example, AWS Simple Storage Service (S3) provides highly-scalable cloud object storage with a simple web service interface. An S3 object can contain both data and metadata, and objects can reside in containers called buckets. Each bucket can be identified by a unique user-specified key or file name. A bucket can be a simple flat folder without a file system hierarchy. A bucket can be viewed as a container (e.g., folder) for objects (e.g., files) stored in the S3 storage resource.

Compute resources **130** can access or otherwise interact with storage resources **132** through network communication paths based on permissions data **136** and/or access control data **138**. System **128** illustratively includes identity and access management (IAM) functionality that controls access to cloud service **108-1** using entities (e.g., IAM entities) provided by the cloud computing platform.

Permissions data **136** includes policies **140** and can include other permissions data **142**. Access control data **138** includes identities **144** and can include other access control data **146** as well. Examples of identities **144** include, but are not limited to, users, groups, roles, etc. In AWS, for example, an IAM user is an entity that is created in the AWS service and represents a person or service who uses the IAM user to interact with the cloud service. An IAM user provides the ability to sign into the AWS management console for interactive tasks and to make programmatic requests to AWS services using the API, and includes a name, password, and access keys to be used with the API. Permissions can be granted to the IAM user to make the IAM user a member of a user group with attached permission policies. An IAM user group is a collection of IAM users with specified permissions. Use of IAM groups can make management of permissions easier for those users. An IAM role in AWS is an IAM identity that has specific permissions, and has some similarities to an IAM user in that the IAM role is an AWS identity with permission policies that determine what the identity can and cannot do in AWS. However, instead of being uniquely associated with one person, a role is intended to be assumable by anyone who needs it. Roles can be used to delegate access to users, applications, and/or services that don't normally have access to the AWS resources. Roles can be used by IAM users in a same AWS account and/or in different AWS accounts than the role. Also, roles can be used by compute resources **130**, such as EC2 resources. A service role is a role assumed by a service to perform actions in an account on behalf of a user. Service roles include permissions required for the service to access the resources needed by the service. Service roles can vary from service to service. A service role for an EC2 instance, for example, is a special type of service role that an application running on an EC2 instance can assume to perform actions.

Policies **140** can include identity-based policies that are attached to IAM identities can grant permissions to the identity. Policies **140** can also include resource-based policies that are attached to resources **126**. Examples include S3 bucket policies and IAM role trust policies. An example trust policy includes a JSON policy document that defines the principles that are trusted to assume a role. In AWS, a policy is an object that, when associated with an identity or resource, defines permissions of the identity or resource. AWS evaluates these policies when an IAM principal user or a role) makes a request. Permissions in the policy determine whether the request is allowed or denied. Policies are often stored as JSON documents that are attached to the IAM identities (user, groups of users, role).

A permissions boundary is a managed policy for an IAM identity that defines the maximum permissions that the identity-based policies can grant to an entity, but does not grant the permissions. Further, access control lists (ACLs) control which principles in other accounts can access the resource to which the ACL is attached. ACLs can be similar to resource-based policies. In some implementations of the technology disclosed, the terms "roles" and "policies" are used interchangeably.

Cloud service **108-1** includes one or more deployed cloud scanners **148**, cloud provider application programming interface(s) (APIs) **150**, a data store **152**, a snapshot generation component **154**, and can include other items **156** as well. Cloud scanner **148** run locally on the cloud-based services and the server systems, and can utilize elastic compute resources, such as, but not limited to, AWS Lambda resources. Cloud scanner **148** is configured to access and scan the cloud service **108-1** on which the scanner is deployed. Examples are discussed in further detail below. Briefly, however, a scanner accesses the data stored in storage resources **132**, permissions data **136**, and access control data **138** to identify particular data patterns (such as, but not limited to, sensitive string patterns) and traverse or trace network communication paths between pairs of compute resources **130** and storage resources **132**. The results of the scanner can be utilized to identify subject vulnerabilities, such as resources vulnerable to a breach attack, and to construct a cloud attack surface graph or other data structure that depicts propagation of a breach attack along the network communication paths.

Given a graph of connected resources, such as compute resources **130**, storage resources **132**, etc., entities (e.g., accounts, roles, policies, etc.), and actors (e.g., users, administrators, etc.), risks and violations against access to sensitive information is identified. A directional graph can be built to capture nodes that represent the resources and labels that are assigned for search and retrieval purposes. For example, a label can mark the node as a database or S3 resource, actors as users, administrators, developers, etc. Relationships between the nodes are created using information available from the cloud infrastructure configuration. For example, using the configuration information, system **122** can determine that a resource belongs to a given account and create a relationship between the policy attached to a resource and/or identify the roles that can be taken up by a user.

Snapshot generation component **154** is configured to generate snapshots **158**, which include representations of databases in storage resources **132**. The snapshots can be generated automatically, such as periodically in response to a time constraint (hourly, daily, etc.). A snapshot includes a read-only point-in-time copy of a database, and includes information suitable to generate a recreation of the database, for example on another server for data posture analysis. This is discussed in further detail below.

As noted above, in some examples, resources **126** can include AWS EC2 and/or Lambda resources. Also, resources **126** can include AWS Instance Stores and/or AWS Elastic Block Store (EBS) volumes. An EBS volume is a durable, block-level storage device that can attach to a compute instance and used as a physical hard drive. In one example, a snapshot **158** can include an EBS snapshot, that is a point-in-time backup copy of an EBS volume stored in an AWS S3 resource. Further, the snapshots can be incremental backups of the data, so that a given snapshot stores changes since a previous snapshot was taken.

Resources **126** can also include an Azure blob identified by a resource URL syntax that assigns each resource a corresponding base URL. A snapshot **158** can include a read-only version of a blob stored as the blob was at the time the snapshot was created. The snapshot **158** can be used to create a backup or checkpoint of a blob, wherein the snapshot blob name includes the base blob URI plus a date-time value that indicates when the snapshot was created.

A cloud storage service or cloud service provider (CSP) can include an organization which hosts services such as networking, software, servers, and/or infrastructure, among others. A CSP can also provide security for the provided services. The services provided by the CSP can relieve a client organization of individual responsibility of setting and managing infrastructure. Examples of CSPs include Amazon Web Services™, Microsoft Azure™, Salesforce™, Google Cloud Platform™, among others.

Cloud provider APIs **150** are configured to receive calls to access various components in cloud service **108**. For example, cloud provider APIs **150** can access snapshots **158** stored in data store **152**. Data store **152** can also store other data items **160** as well.

A CSP generally provides a number of different interfaces to cloud-computing services, such as a service-provider interface to organizational clients for computing services. A CSP, for example, provides interfaces that allow cloud-computing clients to launch virtual machines, application programs, and other computational entities. A CSP can also provide user interface that allow claims to access, through the Internet, the services provided by the CSP. A client of the CSP can deploy web servers to access, modify, and sending information.

A cloud account provided by a CSP includes roles that determine user privileges users and what actions can be taken in the cloud account. An identify and access management (IAM) role is managed by the CSP and provides predefined roles that give granular access to specific CSP resources and prevent unwanted access to other CSP resources. For instance, an AWS IAM role includes an AWS identity with a set of permissions policies that each determine what the role can do within an AWS account. An IAM role can be assumed by anyone who needs requires the role.

For sake of illustration, but not by limitation, a service role can be assumed by an AWS service to perform actions on behalf of users. For instance, as a service that performs backup operations for a client, Amazon Data Lifecycle Manager requires that the client pass in a role to assume when performing policy operations on the client's behalf. That role must have an IAM policy with the permissions that enable Amazon Data Lifecycle Manager to perform actions associated with policy operations, such as creating snapshots and Amazon Machine Images (AMIs), copying snapshots and AMIs, deleting snapshots, and deregistering AMIs. Different permissions are required for each of the Amazon Data Lifecycle Manager policy types. The role must also have Amazon Data Lifecycle Manager listed as a trusted entity, which enables Amazon Data Lifecycle Manager to assume the role.

In examples discussed herein, while a database is accessible using a first authentication requirement (e.g., a username and password), the snapshot **158** generated for that database is accessible (e.g., from data store **152**) using a different authentication requirement (e.g., a cloud provider role through cloud provider APIs **150**). Thus, where a plurality of different sets of authentication credentials (different sets of usernames and passwords) are needed to access a plurality of databases in a given cloud account, a same authentication credential (a cloud provider role) can be utilized to access some or all of those snapshots. This improves efficiency through reduction in network bandwidth and processing load otherwise needed to access all of the data to be analyzed for those databases.

FIG. **3** is a block diagram illustrating one example of cloud security posture analysis system **122**. As noted above, system **122** can be deployed in cloud environment **102** and/or access cloud environment **102** through network **106** shown in FIG. **1**.

System **122** includes a cloud account onboarding component **202**, a cloud scanner deployment component **204**, a cloud data scanning and analysis system **206**, a visualization system **208**, and a data store **210**. System **122** can also include a database connection component **212**, one or more processors or servers **214**, and can include other items **215** as well.

Cloud account onboarding component **202** is configured to onboard cloud services **108** for analysis by system **122**. After onboarding, cloud scanner deployment component **204** is configured to deploy a cloud scanner (e.g., deployed cloud scanner(s) **148** shown in FIG. **2**) to the cloud service. In one example, the deployed scanners are on-demand agent-less scanners configured to perform agent-less scanning within the cloud service. One example of an agent-less scanner does not require agents to be installed on each specific device or machine. The scanners operate on the resources **126** and access management and control system **128** directly within the cloud service, and generate metadata that is returned to system **122**. Thus, in one example, the actual cloud service data is not required to leave the cloud service for analysis.

Cloud data scanning and analysis system **206** includes a metadata ingestion component **216** configured to receive the metadata generated by the deployed cloud scanner(s) **148**. System **206** also includes a query engine **218**, a policy engine **220**, a breach vulnerability evaluation component **222**, one or more application programming interfaces (APIs) **224**, a cloud security issue identification component **226**, a cloud security issue prioritization component **228**, a data schema detection component **229**, a historical resource state analysis component **230**, and can include other items **232** as well.

Query engine **218** is configured to execute queries against the received metadata and generated cloud security issue data. Policy engine **220** can execute security policies against the cloud data and breach vulnerability evaluation component **222** is configured to evaluate potential breach vulnerabilities in the cloud service. APIs **224** are exposed to users, such as administrators, to interact with system **122** to access the cloud security posture data.

Component **226** is configured to identify cloud security issues and component **228** can prioritize the identified cloud security issues based on any of a number of criteria.

Historical resource state analysis component **230** is configured to analyze a history of states of resources **126**. Historical resource state analysis component **230** includes a triggering component **234** configured to detect a trigger that to perform historical resource state analysis. Triggering component **234** is configured to identify an event that triggers component **230** to analyze the state of resources **126**. The event can be, for example, a user input to selectively trigger the analysis, or a detected event such as the occurrence of a time period, an update to a resource, etc. Accordingly, historical resource state can be tracked automatically and/or in response to user input.

Historical resource state analysis component **230** includes a resource configuration change tracking component **236** configured to track changes in the configuration of resources **126**. Component **230** also includes an anomalous state detection component **238**, and can include other items **240** as well. Component **238** is configured to detect the occurrence of anomalous states in resources **126**. A resource anomaly can be identified where a given resource has an unexpected state, such as a difference from other similar resources identified in the cloud service.

Visualization system **208** is configured to generate visualizations of the cloud security posture from system **206**. Illustratively, system **208** includes a user interface component **242** configured to generate a user interface for a user, such as an administrator. In the illustrated example, component **242** includes a web interface generator **244** configured to generate web interfaces that can be displayed in a web browser on a client device.

Visualization system **208** also includes a resource graph generator component **246**, a cloud attack surface graph generator component **248**, and can include other items **250** as well. Resource graph generator component **246** is configured to generate a graph or other representation of the relationships between resources **126**. For example, component **246** can generate a cloud infrastructure map that graphically depicts pairs of compute resources and storage resources as nodes and network communication paths as edges between the nodes.

Cloud attack surface graph generator component **248** is configured to generate a surface graph or other representation of vulnerabilities of resources to a breach attack. In one example, the representation of vulnerabilities can include a cloud attack surface map that graphically depicts propagation of a breach attack along network communication paths as edges between nodes that represent the corresponding resources.

Data store **210** stores metadata **252** obtained by metadata ingestion component **216**, sensitive data profiles **254**, detected data schema records **255**, and can store other items **256** as well. Examples of sensitive data profiles **254** are discussed in further detail below. Briefly, however, sensitive data profiles **254** can identify target data patterns that are to be categorized as sensitive or conforming to a predefined pattern of interest. Sensitive data profiles **254** can be used as training data for data classification performed by data schema detection component **229**. Examples of data classification are discussed in further detail below. For instance, however, pattern matching can be performed based on the target data profiles. Illustratively, pattern matching can be performed to identify instances of data patterns corresponding to social security numbers, credit card numbers, other personal data, medical information, to name a few. In one example, artificial intelligence (AI) is utilized to perform named entity recognition (e.g., natural language processing modules can identify sensitive data, in various languages, representing names, company names, locations, etc.).

Detected data schema records **255** store detected instances of the target data profiles or entities that are returned based on content-based classification of the cloud data. An example detected data schema record **255** can store any of a variety of different data items representing the detected instance corresponding to the data record, including, but not limited to, a data store identifier, a database identifier, a table name identifier, a column name identifier, a column type identifier, a target data entity identifier, and/or a confidence score, among other data. A data store identifier identifies a particular data store that contains the detected instance of the target data profiles. A database identifier identifies a particular database, in the particular data store, that contains the detected instance of the target data profiles. A table name identifier identifies a particular table, in the particular database, that contains the detected instance of the target data profiles. A column name identifier identifies the column name associated with a particular column that contains the detected instance of the target data profiles. A column type identifier identifies a data type (e.g., date, integer, timestamp, character string, decimal, etc.). A target data entity identifier identifies the target data profile that was matched in the detected instance. A confidence score identifies a confidence associated with the classification.

Database connection component **212** is configured to connect to, or access, databases in the data stores of the resources being analyzed by system **122**. This is discussed in further detail below. Briefly, however, database connection component **212** can receive user access credentials, such as a username and password, for each database of a plurality of databases to be accessed in the cloud environment and scanned by the deployed scanners. In another example, database connection component **212** can be configured to connect to representations of the databases that are accessed using a different authentication requirement, than the databases themselves. For example, database connection component **212** can identify and connect to snapshots of the databases through cloud provider APIs **150**, discussed above. Database connection component **212** can access snapshots **158** for the identified databases from data store **152**, and recreate those databases on a server in the cloud environment. The scanners can then be run on the recreated databases, allowing for the scanning of the cloud account data without accessing the actual production environment used by the end users. This can improve security of the scanning process, as well as to reduce processing requirements in obtaining the access credentials for each individual database, and then having to access those databases individually.

FIG. **4** is a block diagram illustrating one example of a deployed scanner **148**. Scanner **148** includes a resource identification component **262**, a permissions data identification component **264**, an access control data identification component **266**, a cloud infrastructure scanning component **268**, a cloud data scanning component **270**, an output component **272**, and can include other items **274** as well. FIG. **4** also illustrates that some or all components of and/or functionality performed by data schema detection component **229** can be on or otherwise associated with deployed scanner **148**.

Resource identification component **262** is configured to identify the resources **126** within cloud service **108-1** (and/or other cloud services **108**) and to generate corresponding metadata that identifies these resources. Permissions data identification component **264** identifies the permissions data **136** and access control data identification component **266** identifies access control data **138**. Cloud infrastructure scanning component **268** scans the infrastructure of cloud service **108** to identify the relationships between resources **130** and **132** and cloud data scanning component **270** scans the actual data stored in storage resources **132**. Output component **272** is configured to output the generated metadata and content-based classification results to cloud security posture analysis system **122**.

The metadata generated by scanner **148** can indicate a structure of schema objects in a data store. For example, where the schema objects comprise columns in a data store having a tabular format, the returned metadata can include column names from those columns. A content-based data item classifier is configured to classify data items within the schema objects, based on content of those data items. This is discussed in further detail below.

FIG. **5** is a flow diagram **300** showing an example operation of system **122** in on-boarding a cloud account and deploying one or more scanners. At block **302**, a request to on-board a cloud service to cloud security posture analysis system **122** is receives. For example, an administrator can submit a request to on-board cloud service **108-1**.

FIG. **6** illustrates one example of a user interface display **304** provided for an administrator. Display **304** includes a display pane **306** including a number of display elements representing cloud accounts that have been on-boarded to system **122**. Display **304** includes a user interface control **308** that can be actuated to submit an on-boarding request at block **302**.

Referring again to FIG. **5**, at block **310**, an on-boarding user interface display is generated. At block **312**, user input is received that defines a new cloud account to be on-boarded. The user input can define a cloud provider identification **314**, a cloud account identification **316**, a cloud account name **318**, access credentials to the cloud account **320**, and can include other input **322** defining the cloud account to be on-boarded.

FIG. **7** illustrates one example of an on-boarding user interface display **324** that is displayed in response to user actuation of control **308**.

Display **324** includes a user interface mechanism **326** configured to receive input to select or otherwise define a particular cloud account provider. In the illustrated example, mechanism **326** includes a plurality of selectable controls representing different cloud providers including, but not limited to, AWS, GCP, Azure.

Display **324** includes a user input mechanism **328** configured to receive input defining a cloud account identifier, and an account nickname. User input mechanisms **330** allow the user to define other parameters for the on-boarding. A user input mechanism **332** is actuated to generate a cloud formation template, or other template, to be used in the on-boarding process based on the selected cloud account provider.

Once the cloud account is connected to system **122**, display **304** in FIG. **6** can be updated to show the details of the cloud account as well as the scan status. In FIG. **6**, each entry includes a display name **334**, an account ID **336**, a data store count **338**, and a risk count **340**. Data store count **338** includes an indication of the number of data stores in the cloud account and the risk count **340** includes an indication of a number if identified security risks. A field **342** indicates the last scan status, such as whether the last scan has completed or whether the scanner is currently in progress or currently scanning. A field **344** indicates the time at which the last scan was completed.

Referring again to FIG. **5**, at block **346**, the cloud account is authorized using roles. For example, administrator access (block **348**) can be defined for the cloud scanner using IAM roles. One or more cloud scanners are defined at block **350** and can include, but are not limited to, cloud infrastructure scanners **352**, cloud data scanners **354**, vulnerability scanners **356**, or other scanners **358**.

At block **360**, the cloud scanners are deployed to run locally on the cloud service, such as illustrated in FIG. **2**. The cloud scanners discover resources at block **362**, scan data in the resources at block **364**, and can find vulnerabilities at block **366**. As discussed in further detail below, a vulnerability can identified based on finding a predefined risk signature in the cloud service resources. The risk signatures can be queried upon, and define expected behavior within the cloud service and locate anomalies based on this data.

At block **368**, if more cloud services are to be on-boarded, operation returns to block **310**. At block **370**, the scan results from the deployed scanners are received. As noted above, the scan results include metadata (block **372**) and/or data item classifications (block **373**) generated by the scanners running locally on the cloud service.

At block **374**, one or more actions are performed based on the scan results. At block **376**, the action includes security issue detection. For example, a breach risk on a particular resource (such as a storage resource storing sensitive data) is identified. At block **378**, security issue prioritization can be performed to prioritize the detected security issues. Examples of security issue detection and prioritization are discussed in further detail below. Briefly, security issues can be detected by executing a query against the scan results using vulnerability or risk signatures. The risk signatures identify criterion such as accessibility of the resources, access and/or permissions between resources, and data types in accessed data stores. Further, each risk signature can be scored and prioritized based impact. For example, a risk signature can include weights indicative of likelihood of occurrence of a breach and impact if the breach occurs.

The action can further include providing user interfaces at block **380** that indicate the scan status (block **382**), a cloud infrastructure representation (such as a map or graph) (block **384**), and/or a cloud attack surface representation (map or graph) (block **386**). The cloud attack surface representation can visualize vulnerabilities.

Remedial actions can be taken at block **388**, such as creating a ticket (block **390**) for a developer or other user to address the security issues. Of course, other actions can be taken at block **392**. For instance, the system can make adjustments to cloud account settings/configurations to address/remedy the security issues.

FIG. **8** illustrates one example of a user interface display **400**, that can be displayed at block **376**. Display **400** provides a dashboard for a user which provides an overview of on-boarded cloud service accounts. The dashboard identifies a number of users **402**, a number of assets **404**, a number of data stores **406**, and a number of accounts **408**. A data sensitivity pane **410** includes a display element **412** that identifies a number of the data stores that include sensitive data, a display element **413** that identifies a number of users with access to the sensitive data, a display element **414** that identifies a number of resources having sensitive data, and a display element **416** that identifies a number of risks on the data stores having sensitive data. Further, graphs or charts can be generated to identify those risks based on factors such as status (display element **418**) or impact (display element **420**).

Display element **420** illustratively categorizes the risks based on impact as well as the likelihood of occurrence of those risks. Risk categorization is discussed in further detail below. Briefly, however, display element **420** stratifies one or more of breach likelihood scores or breach impact scores categories representing different levels of severity, such as high, medium, and low severity levels. In one example, display element **420** is color coded based on the degree of impact of the risk (e.g., high impact is highlighted in red, medium impact is highlighted in yellow, and low impact is highlighted in green).

FIG. **9** is a flow diagram **450** illustrating one example of cloud infrastructure scanning performed by cloud scanner **148** deployed in cloud service **108-1**. At block **452**, an agent-less scanner is executed on the cloud service. The scanner can perform constant time scanning at block **454**.

An example constant time scanner runs an algorithm in which the running time does not depend, or has little dependence on, the size of the input. The scanner obtains a stream of bytes and looks for a multiplicity of patterns (one hundred patterns, two hundred patterns, three hundred patterns, etc.) in one pass through the stream of bytes, with the same or substantially similar performance.

Further, the scanner can return real-time results at block **456**. Accordingly, cloud security posture analysis system **122** receives updates to the security posture data as changes are made to the cloud services.

At block **458**, the scanner discovers the compute resources **130** and, at block **460**, the storage resources **132**. Sensitive data can be discovered at block **462**. The agent-less scanner does not require a proxy or agent running in the cloud service, and can utilize server-less containers and resources to scan the documents and detect sensitive data. The data can be accessed using APIs associated with the scanners. The sensitive data can be identified using pattern matching, such as by querying the data using predefined risk signatures.

At block **464**, access paths between the resources are discovered based on permissions data **136** (block **466**), and/or access control data **138** (block **468**). A rule processing engine, such as using JSON metadata, can be utilized to analyze the roles and policies, and can build access relationships between the nodes representing the resources. The policies can be decoded to get access type (allow, deny, etc.) and the policy can be placed in a node to link from a source to target node and create the access relationship. At block **470**, metadata and/or content-based classification results indicative of the scanning is generated and outputted by output component **272**.

FIGS. **10-1**, **10-2**, **10-3**, and **10-4** (collectively referred to as FIG. **10**) provide a flow diagram **500** illustrating an example operation for streamlined analysis of security posture. For sake of illustration, but not by limitation, FIG. **10** will be discussed in the context of cloud security posture analysis system **122** illustrated in FIG. **3**. Security posture can be analyzed by system **206** using metadata **252** to return from the cloud service scanners.

At block **502**, permissions data and access control data are accessed for pairs of compute and storage resources. The permissions and access control data can include identity-based permissions at block **504**, resource-based permissions at block **506**, or other permissions as well.

At block **508**, network communication paths between the pairs of resources are traced based on the permissions and access control data. For example, the permissions and access control data can identify which paths have read access from a compute resource from a particular compute resource to a particular storage resource, as represented at block **510**. Similarly, paths with write access from compute to storage resources can be identified at block **512**, paths with synchronization access between storage resources can be identified at block **514**. Of course, other types of paths can be identified as well.

For sake of example, but not by limitation, a directional graph is constructed to captures all resources as nodes, with labels assigned to the nodes for search and retrieval. In the AWS example, labels can mark a node as a database or S3 resource. Similarly, labels can represent actors as normal users, admins, developers, etc. Then, known relationships are identified between the nodes, for example using the information available from the cloud infrastructure configuration (e.g., defining a resource belongs to a given account). Similarly, a relationship can be created between the policy attached to a resource, and/or the roles that can be taken up by a user. In addition to storing static information, a rule processing engine (e.g., using JavaScript Object Notation (JSON) metadata) to analyze the roles and policies and build the "access" relationship between the nodes. The analysis can be used to decode the policy to get the access type (e.g., allow, deny, etc.), and the placement of the policy in a node can be used to link from the source node to target node and create the access relationship (e.g., allow, deny, etc.). Similarly, role definitions can be analyzed to find the access type. The graph can therefore include various types of nodes, updated to reflect direct relationships.

An iterative process can be performed to find transitive relationships between resources (e.g., resource access for a given entity/actors/resources). In one example, for each access relationship from a first node N1 to a second node N2, the process identifies all incoming access relationships of N1. Then, the access types targeting node N1 are analyzed and updated. Using the relationships identified to access N1, the relationships to N2 are updated, and a new set of access relationships are identified to N2 through N1. The process continues to proceed to identify all such relationships with the goal of creating relationships to all nodes that have sensitive data.

In one example, block **508** identifies "access types" which include normalized forms of access permissions. For example, an access type "can read" can be defined to include a plurality of different read objects within AWS (e.g., defined in terms of allowable APIs). Similarly, the AWS permissions "PutObject" and "PutObjectAcl" are transformed to a normalized access type "can write" within system **122**.

At block **516**, sensitivity classification data is accessed for objects in the storage resources. The sensitivity classification data can include sensitive data profiles at block **518**.

At block **520**, crawlers can be selected for structured and/or unstructured databases. Crawling the databases can include executing a snapshot of structured databases, creating a dump of structured databases, and scanning the dump for sensitivity classification, as represented at block **524**.

At block **526**, a subset of the pairs of resources are qualified as vulnerable to a breach attack. The qualification can be based on the permissions data at block **528**, the access control data at block **530**, and/or risk criterion at block **532**. The risk criterion can include any of a wide variety of different types of criteria. For example, a risk criterion can indicate a variety of access to the resources at block **534**. One example includes a number of different roles with access to the resource, as represented at block **536**.

Also, a risk criterion can indicate a width of configured access to the resources, at block **538**. For example, the width of configured can include a number of workloads with access to the resources (block **540**) and/or a type of workload with access to the resources (block **542**).

A risk criterion can also indicate a number of users with access to the resources at block **544**, a volume of sensitive data in the resources at block **546**, and/or types of categories of sensitive data at block **548**. Of course, other types of risk criterion can be utilized as well.

In one example, the risk criterion can be defined based on user input. FIG. **11** illustrates one example of a user interface display **550** that facilitates user definition of risk criterion. Display **550** includes a set of user input mechanisms that allows a user to define likelihood weights, represented at numeral **552**, and impact weights, represented at **554**.

For sake of illustration, a first user input mechanism **556** allows a user to set a weight that influences a likelihood score for variations in the variety of access to the resources (e.g., block **534**). Similarly, controls **558**, **560**, and **562** allow a user to set weights that influence likelihood scores for a width of configured access, a number of principles or users with access, and the type of workloads with access, represented by reference numerals **558**, **560**, and **562**, respectively.

Similarly, controls **563**, **564**, **566**, **568**, and **570**, allow a user to set weights on impact scores for risk criterion associated with a volume of sensitive data, a type of sensitive data, and categories of sensitive data (i.e., legal data, medical data, financial data), respectively.

Referring again to FIG. **10**, at block **572**, a first subset of the storage resources that satisfy a subject vulnerability signature are identified. A subject vulnerability signature illustratively includes a risk signature indicative of a risk of vulnerability or breach.

FIG. **12** illustrates an example user interface display **574** that can be accessed from display **304** illustrated in FIG. **6**, and displays a set of risk signatures. The risk signatures can be predefined and/or user-defined. For example, display **574** can include user input mechanisms that allow a user to add, delete, or modify a set of risk signatures **576**. As noted above, each risk signature defines a set of criteria that the resources and data in cloud service **108-1** can be queries upon to identify indications of vulnerabilities in the cloud service. The risk signatures in FIG. **12** include a name field **578**, a unique risk signature ID field **580**, and a description identified in a description field **582**. A result header field **584** identifies types of data that will be provided in the results when the risk signature is matched. A resource field **586** identifies the type of resource, and a tags field **588** identifies tags that label or otherwise identify the risk signature. Additionally, a likelihood factor field **590** indicates a likelihood factor that is assigned to the risk signature and an impact factor signature **592** indicates an impact factor assigned to the risk signature. The likelihood factor indicates a likelihood assigned to occurrence of the risk signature and the impact factor assigns an impact to the cloud service assigned to the occurrence of the risk signature. For sake of illustration, a likelihood factor of ten (out of a scale of ten) indicates that the vulnerability is likely to occur if the risk signature is identified in the cloud posture data, whereas a likelihood factor of one indicates a low likelihood. Similarly, an impact factor of ten (out of a scale of ten) indicates that the vulnerability is considered to have a high impact, whereas an impact factor of one indicates the vulnerability is considered to have a low impact on the cloud service.

A risk signature can be defined based upon any of a wide variety of criteria. For example, a risk signature can identify one or more configurations or settings of compute resources **130**. Examples include, but are not limited to, a configuration that indicates whether the compute resource provides accessibility to a particular type of data, such as confidential data, medical data, financial data, personal data, or any other type of private and/or sensitive content. In another example, a risk signature indicates that a compute resource is publicly accessible, includes a public Internet protocol (IP) address, or has IP forwarding enabled. In another example, a risk signature indicates that a compute resource has monitoring disabled, has no IAM role assigned to the compute resource, has backup disabled, data encryption disabled, and/or a low or short backup retention policy. Also, a risk signature can identify password policies set for the compute resource. For instance, a risk signature can indicate a lack of minimum password policies, such as no minimum password length, no requirement of symbols, lowercase letters, uppercase letters, numbers, or password reuse policy. Also, a risk criterion can indicate a location of the compute resource, such as whether the compute resource is located outside of a particular region.

Risk signatures can also indicate configurations and/or settings of storage resources **132**. For example, the configurations and settings can indicate authentication or permissions enforced by the storage resource, such as whether authentication is required for read, write, delete, synchronization, or any other operation. Also, the risk signature can indicate whether multi-factor authentication is disabled for the storage resource, as well as a breadth of permissions grants (e.g., whether all authenticated users are granted permissions within the storage resource). Also, a risk signature can indicate whether encryption is enabled by default, a password policy enforced by the storage resource, whether the storage resource is anonymously accessible, publicly accessible, has a key management service disabled, has logging disabled, life cycle management disabled, whether the storage resource is utilized for website hosting, has geo-restriction disabled, or has backup functionality disabled. Also, the risk signature can indicate a type of data stored by the storage resource, such as the examples discussed above.

Referring again to FIG. **10**, the first subset of storage resources identified at block **572**, are based on determining that the storage resources satisfy a risk signature of containing private and/or sensitive content, as represented at block **594**. In another example, the subject vulnerability signature is based on a prevalence of accessibility of a given role within a network exceeding a set threshold, as represented at block **596**. For instance, the given role can include principles (block **598**), workloads (block **600**), a cloud environment (block **602**), a company (block **604**), or other roles (block **606**).

Also, the subject vulnerability signature can indicate that the storage resources are accessible by more than a threshold number of users, as represented at block **608**. Also, the subject vulnerability signature can indicate that the storage resources are accessible by a vulnerable compute resource that is publicly accessible, as represented at block **610**. This determination can be based on identifying that the compute resource is accessible through a public portal, at block **612** and/or is accessible by users outside a given company network at block **614**.

As represented at block **616**, the subject vulnerability signature can indicate that the storage resources are accessible by inactive users. For example, inactive users can include users who have not accessed the resources within a threshold time, at block **618**.

At block **620**, a second subset of storage resources are identified that synchronization data from the first subset. At block **622**, a particular compute resource is determined to have anomalous access to a given storage resource. The identification of anomalous access can be based on a comparison of a network communication path of the particular compute resource against paths of other compute resources. For example, the paths of other compute resources can be used to identify an expected communication path for the particular compute resource and/or expected permission for the particular resource. Then, if a difference above a threshold is identified, the particular compute resource is identified as anomalous.

At block **624**, a representation of the propagation of the breach attack along the network communication paths is generated. In one example, the representation includes a cloud attack surface map, as represented at block **626**. An example cloud attack surface map includes nodes representing the resources (block **628**) and edges representing the breach attack propagation (block **630**). The map graphically depicts the subset of storage resources (block **632**) and the subject vulnerability signature (block **634**). Also, the map can graphically depict the anomalous access to the particular compute resource (block **636**). For example, public accesses to the subset of storage resources can be graphically depicted at block **638** and storage resources that grant external access and/or resources that are initialized from outside a particular jurisdiction can be identified at blocks **640** and **642**, respectively.

FIG. **13** illustrates one example of a user interface display **650** that graphically depicts vulnerability risks, in tabular form. In one example, display **650** renders the data discussed with respect to the cloud attack surface at block **626** of FIG. **10** in a table.

Display **650** includes a user input mechanism **652** to specify a time range for visualizing the risk, and includes a description **654**, a resource identifier **656**, and an account identifier **658** for the cloud service account. The display can also indicate the impact **660** and likelihood **662** of the vulnerability risk, as well as signature identifier **664** that identifies the particular risk signature that was matched. Display **650** also includes a details control **666** that is actuatable to display details of the identified risk. One example of a details display pane **668** is illustrated in FIG. **14**. Display pane **668** shows a description of the risk at display element **670** and an indication **672** of the query utilized to match the risk signature.

Referring again to FIG. **10**, at block **676**, a query is received for execution against the results of the metadata analysis. For example, a query can specify a subject vulnerability at block **678** and/or the query can request identification of resources with anomalous access at block **680**.

At block **682**, the query is executed against the cloud attack surface map. For example, the cloud attack surface map can be filtered to identify results that match the query. The query results (e.g., the filtered map) is returned at block **684**. The filtered results can include identifying a subset of storage resources that match the query (block **686**) and/or resources having anomalous access at block **688**.

The cloud attack surface graph is graphically filtered based on the results at block **690**. For example, the graph can be filtered based on applications running on the pairs of resources in the identified subset (block **692**). Breach likelihood scores and breach impact scores are determined for the resources at block **694**, and the scores can be depicted on the cloud attack surface map at block **696**. In one example, the scores are graphically categorized or stratified at block **698** into high, medium, or low risk. One example is discussed above with respect to FIG. **8**.

FIG. **15** illustrates one example of a user interface display **700** configured to graphically depict breach likelihood and impact scores. Display **700** identifies data stores in storage resources **132** that are identified as meeting a subject vulnerability. Each entry shown in display **700** identifies a type **702** of the resource, an impact score **704**, a likelihood score **706**, a resource identifier **708** that identifies the resource, and a cloud service identifier **710** that identifies the particular cloud resource. Based on actuation of a risk item view generator mechanism **712**, display **700** shows details for the given resource in a details display pane **714**, as shown in FIG. **16**. Details display pane **714** can show users **716** that have access to the resource, roles **718** that have access to the resource, other resources **720** that have access to the resource, as well as external users **722** or external roles **724**. Details display pane **714** also shows the access type **726**.

FIG. **17** illustrates a user interface display **800** that includes a visualization of access communication paths. The visualization in FIG. **17** can be rendered as a cloud infrastructure graph (e.g., map) that shows relationships between compute and storage resources and/or mappings between users, roles, and resources, based on the permissions data and the access control data. Further, the visualization can be augmented using sensitivity classification data to represent propagation of breach attack along communication paths. For example, the visualization in FIG. **17** can be configured to render the subset(s) of resources identified in FIG. **10**. That is, display **800** can include the cloud attack surface map at block **626**.

As shown in FIG. **17**, nodes **802** represent compute resources and nodes **804** represent storage resources. Illustratively, the storage resources include data stores or buckets within a particular cloud service. Nodes **806** represent roles and/or users. The links (e.g., access paths) or edges **808** between nodes **802** and **806** represent that compute resources that can access the particular roles represented by nodes **806**. The edges or links **810** represent the storage resources that can be accessed by the particular roles or users represented by nodes **806**.

Based on these relationships between compute and storage relationships, display elements can be rendered along, or otherwise visually associated with, the edges **808** and/or **810**, to identify and graphically depict the propagation of breach attack. For instance, vulnerability display elements can be rendered in association with edges **808** and/or **810** to identify that a subject vulnerability signature (e.g., one or more risk signatures shown in FIG. **12**) has been identified in the data, based on querying the permissions and access control data using the subject vulnerability signature. For example, display element **809** represents a risk signature between nodes **803** and **812** and display element **811** represents (such as by including a description, icon, label, etc.) a risk signature between nodes **812** and **822**. Each display element **809**, **811** can represent (such as by including a description, icon, label, etc.) corresponding likelihood and impact scores, can be actuatable to render details of the subject vulnerability, such as in a display pane on display **800**. The details can include which risk signature has been matched, which sensitive data is at risk, etc.

The graph can be interactive at a plurality of different resolutions or levels. For example, a user can interact with the graph to zoom into a specific subset, e.g., based on cloud vendor concepts of proximity (regions, virtual private clouds (VPCs), subnets, etc.). Node **812** includes an expand actuator **814** that is actuatable to expand the display to show additional details of the roles, role groups, and/or users represented by node **812**.

When zooming into one region, such as when using the actuators discussed below, other regions can be zoomed out. This can be particularly advantageous when handling large diagrams. Further, the graph includes one or more filter mechanisms configured to filter the graph data by logical properties, such as names, values of various fields, IP addresses, etc. For example, a free form search box **815** is configured to receive search terms and filter out all resources (e.g., by removing display of those resources) except those resources matching the search terms. In one example, the search terms include a subject vulnerability signature (e.g., containing private and sensitive content, public accessibility, accessibility by a particular user and/or role, particular applications running on the resources, access types, etc.).

An input mechanism **817** is configured to receive a temporal filter or search criterion. For example, a filter criterion is entered by a user to represent at least one of a creation time or date of computer resources and storage resources. Further, a query can be entered specifying at least one temporal period, wherein the cloud infrastructure map is updated to graphically return at least one prior state (e.g., a permissions state, an access control state, and/or a sensitivity data classification state) of compute resources and storage resources based on the temporal period.

A checkbox (not shown in FIG. **17**, and which can be global to the diagram) provides the ability to toggle whether or not direct neighbors of the matching resources are also displayed, even if those neighbors themselves don't match the search terms. This allows users to search for specific resources and immediately visualize all entities that have access to the searched resources. To illustrate, assume a search for personally identifiable information (PII) matches a set of S3 buckets. In this case, the graph renders resources that have access to that PII. Further, the graph can show associated data and metadata (e.g., properties extracted from cloud APIs, properties derived such as presence of sensitive data, access paths, etc.). This data and metadata can be shown on a panel to the left or right of the diagram. Further, user can actuate user interface controls to collapse/expand this panel. In one example, the panel remains collapsed or expanded until changed, even across different searches and login sessions. Additionally, the display can groups properties in related categories (e.g., summary, all metadata retrieved from the cloud, all metadata derived, local annotations, etc.), and the diagram can be filtered (such as by using the free form search bar mentioned above) by metadata such as tags, applications running on them, identified owners, time since created, etc.). The state of the resources can be shown as of a user defined date or time. A calendar component can allow users to select a particular date to visualize historical state data as of that particular date.

Referring again to FIG. **17**, the nodes **804** representing the storage resources are also actuatable to show additional details. For example, node **822** includes an actuator **824** that is actuatable to display a view of the constituents of the storage resource represented by node **822**. One or more of the elements are further actuatable to show additional details of the constituent.

FIG. **18** illustrates one example of data schema detection component **229**. Component **229** includes a data store accessing component **902**, a context-based classifier **904**, a content-based classifier **906**, a classifier training component **908**, a control signal generator **910**, a data store **912**, one or more processors or servers **914**, and can include other items **916** as well.

Data store accessing component **902** is configured to access data stores to be analyzed. Context-based classifier **904** includes a schema detector **920**, a metadata generator **922**, and can include other items **924** as well. Schema detector **920** is configured to detect a schema used by the data store, and includes a schema parsing component **926**, which includes a schema object detector **928**. For sake of illustration, but not by limitation, in an example structured database, the data stores store data according to a defined format, such as a table format, JavaScript object notation (JSON), to name a few. The data stores can be accessed using a database management system, such as mySQL, Mongo DB, to name a few. Thus, schema object detector **928** identifies the particular schema objects in the database structure and metadata generator **922** generates metadata that identifies the detected schema objects along with relationship data that identifies relationships between those schema objects. The metadata can be stored as metadata **930** in data store **912**.

However, in some instance, the metadata can provide some level of context, but may not accurately represent the actual content items. For example, the returned metadata can include column names of columns in a tabular data store, but the column names may not accurately represent the actual data items in the corresponding columns. For instance, sensitive data, such as financial data, personal data, etc. can be stored in a column having a column name that identifies the column as including something other than sensitive data (e.g., a customer phone number can be stored in a product description column). In turn, data posture analysis performed using such metadata can be inaccurate and fail to identify potential data security vulnerabilities.

Content-based classifier **906** is configured to perform content-based classification to classify data items in the schema objects identified by context-based classifier **904**. Content-based classifier **906** includes a schema object accessing component **932**, a target data entity comparison component **934**, a result generator **936**, a confidence score generator **938**, and can include other items **939** as well. Schema object accessing component **932** is configured to access the schema objects detected by schema object detector **928**. For example, component **932** can identify and access columns in a table using the stored metadata **930**.

Data store **912** can also store training data **940**, classifier result records **941**, and can store other items **942** as well. Training data **940** illustratively includes target data profiles (also referred to as target data profiles or entities **940**) that represent a collection of different data types to be used in performing the content-based classification. For example, training data **940** can include sensitive data profiles **254**, which can represent sensitive data types, patterns, and/or signatures. Examples include various types of financial data, such as, but not limited to, credit card numbers, bank account numbers, etc. Also, the training data **940** can identify personal information, such as social security numbers, phone numbers, email addresses, etc.

For sake of illustration, but not by limitation, an example target data profile for an internet protocol (IP) address indicates a form "x.x.x.x", where x is an octet and must be a decimal value between zero and two hundred and fifty five. As another example, a target data profile for a credit card number indicates a string of fifteen or sixteen characters that begins with a three, four, or five.

Training data **940** be stored, updated, and removed in any of a number of ways. For example, a user can define new target data profiles to be detected, modify existing target data profiles, etc.

Content-based classifier **906** can perform content-based classification using target data entity comparison component by comparing the data items to predefined target data profiles. Classifier training component **908** is configured to training the content-based classifier by using the training data **940**. The content-based classifier can be any of a wide variety of classifiers including, but not limited to, a rules-based classifier, a machine learned classifier (e.g., a deep learning system), a heuristics-based classifier, or other type of classifier or classification model.

An example classifier includes a classification engine that evaluates extracted content, extracted from the schema objects, and content metadata based on a content rule or model, trained with the training data. For example, a portion of content can be matched to a content rule if a characteristic of the content satisfies a condition of the content rule. For instance, a classifier can compare the extracted content to the target data profiles using one or more similarity measures. A similarity measure can be used by the classifier to determine whether a data item extracted from a content object is determined to match a given target data profile. Examples of similarity measures include, but are not limited to, k-gram overlap, edit distance, Cosine similarity, Manhattan distance, Euclidean distance, Levenshtein distance, to name a few.

FIG. **19** is a flow diagram **1000** illustrating one example of scanning data stores in a cloud environment. For sake of illustration, but not by limitation, FIG. **19** will be discussed in the context of cloud security posture analysis system **122**.

At block **1002**, system **122** accesses a cloud account in a cloud environment onboarded by cloud account onboarding component **202**. Onboarding can be done in any of a number of ways. For example, the cloud environment can be accessed through a cloud provider application programming interface (API) at block **1004**. The cloud environment can also be accessed using open port numbers at block **1006**. Of course, the cloud environment can be accessed in other ways as well, as represented at block **1008**.

At block **1010**, a plurality of data stores is identified in the cloud environment. In one example, the plurality of data stores includes a set of data storage servers. Thus, each data store can include a server having one or more databases logically defined thereon, as represented at block **1012**.

At block **1014**, a user interface display is generated that displays the identified data stores. One example of a user interface display **1016** is illustrated in FIG. **20**. As shown in FIG. **20**, user interface display **1016** includes a display pane **1018** that displays the plurality of identified data stores in a tabular format. Each of a plurality of entries is a row in pane **1018** and represents one of the data stores. A plurality of columns in pane **1018** identify a name (column **1020**) of the data store, a type (column **1022**) of the data store, a volume (column **1024**) of the data store, and a storage engine (column **1026**) used by the data store. Each entry can also include a likelihood metric (column **1028**) and an impact metric (column **1030**), that indicate breach likelihood and breach impact, respectively, for that data store. Examples of determining breach likelihood and impact are discussed above.

Each entry can also identify detected entities (e.g., detected instances of target data profiles **940**) in the data store. In the illustrated example, column **1032** includes one or more display elements **1033**, where each display element **1033** represents a particular target data profile along with a numeric representation of how many instances of the target data profile have been detected in the particular data store. For instance, in FIG. **20**, nine instances of the "domain_name" profile have been detected in the data store ABC. The display elements can be actuatable to navigate the user to the corresponding instances in the data store.

Each entry can also identify detected composite profiles identified in the data store. In the illustrated example, column **1034** includes one or more display elements **1035**, wherein each display element **1035** represents a particular composite profile along with a numeric representation of how many instances of the target data profile have been detected in the particular data store. A composite profile includes combinations of target data profiles (e.g., profiles **940**). Examples are discussed below. Briefly, a composite profile can include two or more different data entities within a threshold proximity (e.g., a same row in a table, a threshold number of words, etc.). For instance, in FIG. **20**, twenty-three instances of the "person" profile have been detected within a threshold proximity of the "email" profile in the data store ABC.

A user can navigate to display pane **1018** to visualize the structured databases through actuation of a structured database control **1036**. The user can also navigate between the data stores, databases, tables, and columns within the data store, through a set of controls **1038**.

Referring again to FIG. **19**, at block **1040**, one or more data stores are selected to scan. At block **1042**, one or more scanners are connected to each selected data store. Connecting a data store can be performed in any of a number of ways. At block **1044**, access credentials can be obtained for each selected data store. For example, the user can enter a username and password for a data store, which is stored by the scanner to obtain access to the data for subsequent scanning.

In another example, at block **1046**, the scanner can be downloaded and run locally on the data store. At block **1048**, a role can be provided to the scanner, which allows the scanner to access data stores in the cloud environment through the role (such as a cloud provider role, etc.). Of course, a scanner can be connected to the data stores in other ways as well, as represented at block **1050**.

In FIG. **20**, one example of selecting a data store includes user actuation of a database selection control **1052**. In response to actuation of control **1052**, a user interface is displayed for connecting the data store corresponding to the selected control **1052** (data store "ABC" in the present example). FIG. **21** illustrates one example of a user interface display **1054** for connecting the data store.

As shown in FIG. **21**, user interface display **1054** includes a data store connection display tab **1056** actuatable to provide user input mechanisms **1058** for entering access credentials for the data store. User input mechanisms **1058** include a connection type input mechanism **1060** actuatable to select the connection type, for example from a drop-down menu. In the example of FIG. **21**, a "username/password" connection type is selected, and a username input mechanism **1062** and a password input mechanism **1064** are rendered for receiving a username and password, respectively, for the data store "ABC". The user enters the username and password and submits the access credentials by actuating control **1066**. FIG. **22** illustrates user interface display **1054** where a user has actuated mechanism **1060** and is provided with a set of selectable connection type options **1068**. Here, a drop-down menu includes, in addition to the username/password connection type, a standalone scanner connection type **1070** actuatable to download and run the scanner locally on the data store. Another connection type control **1072** is selectable to provide a cloud provider role to the scanner for accessing the data store.

Referring again to FIG. **19**, at block **1074** the scanner is run on the data store to perform context-based classification at block **1076** and content-based classification at block **1078**. At block **1080**, results are returned representing the data posture and one or more actions are performed based on the results at block **1082**. For example, one or more user interfaces can be generated at block **1084** providing the results of the scan, as well as providing user input mechanisms for a user to interact with the results, for example to drill up or drill down in the results, perform remedial actions, etc. At block **1088**, security issue detection can be performed to detect security issues based on the scan results. In one example, security issue prioritization is performed at block **1090**. Examples of security issue detection and prioritization are discussed above. Remedial actions are illustrated at block **1092**. Of course, other actions can be performed at block **1094**.

FIGS. **23-1** and **23-2** (collectively referred to as FIG. **23**) provide a flow diagram **1100** illustrating one example of performing content-based classification of data items. For sake of illustration, but not by limitation, FIG. **23** will be discussed in the context of cloud security posture analysis system **122**.

At block **1101**, content-based classifier **906** is trained based on training data **940**. At block **1102**, a data store is accessed using, for example, the access credentials obtained at block **1044** and/or the role provided at block **1048**. At block **1104**, databases in the data store are enumerated, for example based on metadata **930** obtained from data store **912**. For instance, the metadata **930** can identify a location of and/or include a link to each database.

A first database is selected from the enumerated databases at block **1106** and the database is scanned at block **1108**. At block **1110**, metadata is returned representing the data schema. For instance, relationship data representing a relationship between a set of schema objects in the database is returned. The metadata can identify all the tables in the database at block **1111**, and all columns in each table at block **1112**. Also, the metadata can identify column labels and/or a column description at block **1113**, and the metadata can identify column data types at block **1114**. Of course, other metadata can be retuned as well, as represented at block **1115**.

At block **1116**, content-based data scanning is performed on the schema objects using the metadata return at block **1110**. For example, based on the metadata, all schema objects (e.g., all tables and columns) are enumerated and accessed to classify data items in the schema object at block **1117**. In one example, at block **1118**, the data is classified based on one or more target data entities, such as one or more of sensitive data profiles **254**. Thus, block **1118** identifies instances of data profiles **254** in a schema object. At block **1119**, instances of composite data signatures or profiles can be detected. For example, a composite data profile can include two or more detected entities within a threshold proximity (e.g., a same row in a table, a threshold number of words, etc.). Thus, block **1119** obtains the threshold proximity and scans the schema object for occurrences of two or more data profiles within the threshold proximity. For instance, for a "person_n_email" composite data profile, block **1119** scans a table for occurrences of the "person" profile and the "email" profile within a same row of the table. In some instances, an occurrence of a single data profile can indicate a low or moderate data security risk. However, an occurrence of the same data profile in combination with another data profile can indicate of high data security risk. To illustrate, a name or address alone may not be considered personal identifiable information (PII), but a name and address together in a row may be considered PII.

Accordingly, usage of composite data profiles can increase the fidelity of the sensitivity of data that is detected and classified.

In one example of block **1118**, metadata **930** is obtained from data store **912** and used to identify a structure of schema objects in the first database. For instance, the metadata **930** can identify a number of tables and respective columns in the first database. Using this metadata, classifier **960** iteratively selects each column and determines whether any data items in the selected column matches one of the target data profiles to within a similarity measure.

FIGS. **24-1** and **24-2** (collectively referred to as FIG. **24**) provide a flow diagram **1200** of an example operation of a cloud data schema detection system that performs data posture analytics using snapshotting. For sake of illustration, but not by limitation, FIG. **24** will be discussed in the context of cloud security posture analysis system **122**.

At block **1202**, a user interface is generated to connect one or more databases to cloud security posture analysis system **122**. Examples of user interface displays for selecting databases to connect to the cloud security posture analysis system are discussed above with respect to FIGS. **20-22**.

As noted above, an example database on a server in cloud environment **102** is accessible using a first authentication requirement. Accessing a server using a first authentication requirement is represented at block **1204**. The authentication requirement can include a user-based authentication credential at block **1206**. For instance, the authentication credential can include secret data, such as a username and password at block **1208**. Of course, other authentication credentials can be utilized to access a database in a cloud environment, as represented at block **1210**.

FIG. **25** illustrates one example of a cloud environment **1300** having a plurality of data stores **1302** in a production environment **1304**. Data stores **1302** include a first data store **1302-1**, a second data store **1302-2**, and can include any of a number of additional data stores **1302**-N. Each data store of the plurality of data stores **1302** can include a data storage server having a plurality of databases logically defined thereon. For example, data store **1302-1** includes a first database **1306-1**, and second database **1306-2**, and any of a number of additional databases **1306**-N (collectively referred to as databases **1306** on data store **1302-1**). Similarly, data store **1302-2** can include a plurality of databases **1308-1**, **1308-2**, and **1308**-N.

The databases in production environment **1304** are accessible by any of a number of actors, such as actors **104** shown in FIG. **1**. The databases are accessible to, for example, read data, write data, modify data, etc. The databases are accessible using authentication requirements in a first set of authentication requirements **1310**. Authentication requirements **1310** illustratively include a plurality of individual authentication requirements, each authentication requirement pertaining to a different one (or more) of the databases. For sake of illustration, but not by limitation, the authentication requirements will be discussed in the context of a user-based authentication credential, such as a username and password. Of course, other types of authentication credentials can be utilized as well.

As illustrated, a first authentication credential **1312-1** is required to access database **1306-1**, a second authentication credential **1312-2** is required to access database **1306-2**, a third authentication credential **1312-3** is required to access database **1306**-N, etc. According, as can be seen in FIG. **25**, for a production environment having a large number of databases, a large number of authentication requirements are required to access the data on those databases.

Snapshot generation component **154** is configured to access the databases in data stores **1302** to generate snapshots **158** in a non-production environment **1313**, that are stored in data store **152**. For example, snapshot generation component **154** can be configured to generate snapshot **158-1** representing database **1306-1** periodically, such as every hour, day, week, etc.

The non-production environment **1313** is illustratively a separate environment from production environment **1304**. In some instances, environment **1313** can be considered an offline environment relative to the production environment **1304**, in that the snapshots **158** are generally not accessed in real-time by end users who access data stores **1302**.

Snapshots **158** are accessible using a second authentication requirement **1314**, that is different than the authentication requirements in the first set of authentication requirements **1310**. In the present example, snapshots **158** are accessible using an authentication requirement other than a user-based authentication credential.

In the example of FIG. **25**, the second authentication requirement **1314** includes a cloud provider role through a cloud provider API **1316**. Thus, an interface **1318** in the cloud environment can access, analyze, and display the snapshots **158** in data store **152**. For example, a particular snapshot **158-1** can be retrieved from data store **152** and utilized to recreate database **1306-1** on a server, separate from the data store server that includes data store **1302-1**.

Referring again to FIG. **24**, at block **1212**, a request to connect a plurality of databases (e.g., databases **1306**, **1308**) in a cloud account is received. Cloud provider API **1316** is accessed at block **1214** to discover, at block **1216**, a plurality of snapshots **158** corresponding to the databases in data stores **1302**. As noted above, a snapshot can include a read-only point-in-time copy of a database, as represented at block **1218**. Further, each snapshot is accessible using the second authentication requirement **1314**, as represented at block **1220**.

At block **1222**, the snapshots are accessed using the cloud provider role through the cloud provider interface. Accordingly, a same authentication requirement can be utilized to access numerous snapshots (for some or all) of the databases to be analyzed. This removes any requirement to obtain access credentials for each database individually, which reduces the need of a user experience to receive, store, and transmit all of the access credentials for the databases, and can also improve data security as it does not require the user to provide all of the access credentials to the servers in the production environment.

At block **1224**, a particular snapshot (corresponding to a respective one of the databases) is selected and used to generate, at block **1226**, a representation of the respective database. For example, the respective database is recreated on a second server, separate from the server having the datastore on which the database is stored. This is represented at block **1228**.

At block **1230**, it is determined whether there are any additional snapshots. If so, operation returns to block **1224**. At block **1232**, each database representation, generated from the snapshots, is scanned. In the illustrated example, scanning the database includes scanning the recreated database on the server.

At block **1236**, a data posture analyzer is applied. Examples are discussed above. For sake of illustration, in one example, the analyzer analyzes the data based on metadata representing a structure of schema objects in the database, as represented at block **1238**. Alternatively, or in addition, a content-based classifier can be applied to the data. Of course, the data can be analyzed in other ways as well, as represented at block **1242**.

At block **1244**, an analysis result is generated, which can include storing the data posture analysis, generating a user interface that renders the analysis result, or any other output or actions relative to the data posture analysis result.

It can thus be seen that the present disclosure describes technology for security posture analysis of a cloud account. In some described examples, the technology can discover sensitive data among the cloud storage resources and as well as access patterns to the sensitive data, using local scanners that reduce or eliminate need to send the cloud data outside the cloud environment. This improves data security. Further, the technology facilitates the discover of security vulnerabilities to understand the data security posture, detect, and remediate the security vulnerabilities, and to prevent future breaches to sensitive data. The system provides real-time visibility and control on the control data infrastructure by discovering resources, sensitive data, and access paths, and tracking resource configuration, deep context, and trust relationships in real-time as a graph or other visualization.

One or more implementations of the technology disclosed or elements thereof can be implemented in the form of a computer product, including a non-transitory computer readable storage medium with computer usable program code for performing the method steps indicated. Furthermore, one or more implementations and clauses of the technology disclosed or elements thereof can be implemented in the form of an apparatus including a memory and at least one processor that is coupled to the memory and operative to perform exemplary method steps. Yet further, in another aspect, one or more implementations and clauses of the technology disclosed or elements thereof can be implemented in the form of means for carrying out one or more of the method steps described herein; the means can include (i) hardware module(s), (ii) software module(s) executing on one or more hardware processors, or (iii) a combination of hardware and software modules; any of (i)-(iii) implement the specific techniques set forth herein, and the software modules are stored in a computer readable storage medium (or multiple such media).

Examples discussed herein include processor(s) and/or server(s). For sake of illustration, but not by limitation, the processors and/or servers include computer processors with associated memory and timing circuitry, and are functional parts of the corresponding systems or devices, and facilitate the functionality of the other components or items in those systems.

Also, user interface displays have been discussed. Examples of user interface displays can take a wide variety of forms with different user actuatable input mechanisms. For instance, a user input mechanism can include icons, links, menus, text boxes, check boxes, etc., and can be actuated in a wide variety of different ways. Examples of input devices for actuating the input mechanisms include, but are not limited to, hardware devices (e.g., point and click devices, hardware buttons, switches, a joystick or keyboard, thumb switches or thumb pads, etc.) and virtual devices (e.g., virtual keyboards or other virtual actuators). For instance, a user actuatable input mechanism can be actuated using a touch gesture on a touch sensitive screen. In another example, a user actuatable input mechanism can be actuated using a speech command.

The present figures show a number of blocks with corresponding functionality described herein. It is noted that fewer blocks can be used, such that functionality is performed by fewer components. Also, more blocks can be used with the functionality distributed among more components. Further, the data stores discussed herein can be broken into multiple data stores. All of the data stores can be local to the systems accessing the data stores, all of the data stores can be remote, or some data stores can be local while others can be remote.

The above discussion has described a variety of different systems, components, logic, and interactions. One or more of these systems, components, logic and/or interactions can be implemented by hardware, such as processors, memory, or other processing components. Some particular examples include, but are not limited to, artificial intelligence components, such as neural networks, that perform the functions associated with those systems, components, logic, and/or interactions. In addition, the systems, components, logic and/or interactions can be implemented by software that is loaded into a memory and is executed by a processor, server, or other computing component, as described below. The systems, components, logic and/or interactions can also be implemented by different combinations of hardware, software, firmware, etc., some examples of which are described below. These are some examples of different structures that can be used to implement any or all of the systems, components, logic, and/or interactions described above.

The elements of the described figures, or portions of the elements, can be disposed on a wide variety of different devices. Some of those devices include servers, desktop computers, laptop computers, tablet computers, or other mobile devices, such as palm top computers, cell phones, smart phones, multimedia players, personal digital assistants, etc.

FIG. **26** is a simplified block diagram of one example of a client device **1400**, such as a handheld or mobile device, in which the present system (or parts of the present system) can be deployed. FIG. **27** illustrates an example of a handheld or mobile device.

One or more communication links **1402** allows device **1400** to communicate with other computing devices, and can provide a channel for receiving information automatically, such as by scanning. An example includes communication protocols, such as wireless services used to provide cellular access to a network, as well as protocols that provide local wireless connections to networks.

Applications or other data can be received on an external (e.g., removable) storage device or memory that is connected to an interface **1404**. Interface **1404** and communication links **1402** communicate with one or more processors **1406** (which can include processors or servers described with respect to the figures) along a communication bus (not shown in FIG. **26**), that can also be connected to memory **1408** and input/output (I/O) components **1410**, as well as clock **1412** and a location system **1414**.

Components **1410** facilitate input and output operations for device **1400**, and can include input components such as microphones, touch screens, buttons, touch sensors, optical sensors, proximity sensors, orientation sensors, accelerometers. Components **1410** can include output components such as a display device, a speaker, and or a printer port.

Clock **1412** includes, in one example, a real time clock component that outputs a time and date, and can provide timing functions for processor **1406**. Location system **1414** outputs a current geographic location of device **1400** and can includes a global positioning system (GPS) receiver, a LORAN system, a dead reckoning system, a cellular triangulation system, or other positioning system. Memory **1408** stores an operating system **1416**, network applications and corresponding configuration settings **1418**, communication configuration settings **1420**, communication drivers **1422**, and can include other items **1424**. Examples of memory **1408** include types of tangible volatile and non-volatile computer-readable memory devices. Memory **1408** can also include computer storage media that stores computer readable instructions that, when executed by processor **1406**, cause the processor to perform computer-implemented steps or functions according to the instructions. Processor **1406** can be activated by other components to facilitate functionality of those components as well.

FIG. **27** illustrates one example of a tablet computer **1450** having a display screen **1452**, such as a touch screen or a stylus or pen-enabled interface. Screen **1452** can also provide a virtual keyboard and/or can be attached to a keyboard or other user input device through a mechanism, such as a wired or wireless link. Alternatively, or in addition, computer **1450** can receive voice inputs.

FIG. **28** shows an example computer system **5000** that can be used to implement the technology disclosed. Computer system **5000** includes at least one central processing unit (CPU) **5072** that communicates with a number of peripheral devices via bus subsystem **5055**. These peripheral devices can include a storage subsystem **5010** including, for example, memory devices and a file storage subsystem **5036**, user interface input devices **5038**, user interface output devices **5076**, and a network interface subsystem **5074**. The input and output devices allow user interaction with computer system **5000**. Network interface subsystem **5074** provides an interface to outside networks, including an interface to corresponding interface devices in other computer systems.

In one implementation, cloud security posture analysis system **5018** is communicably linked to the storage subsystem **5010** and the user interface input devices **5038**.

User interface input devices **5038** can include a keyboard; pointing devices such as a mouse, trackball, touchpad, or graphics tablet; a scanner; a touch screen incorporated into the display; audio input devices such as voice recognition systems and microphones; and other types of input devices. In general, use of the term "input device" is intended to include all possible types of devices and ways to input information into computer system **5000**.

User interface output devices **5076** can include a display subsystem, a printer, a fax machine, or non-visual displays such as audio output devices. The display subsystem can include an LED display, a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), a projection device, or some other mechanism for creating a visible image. The display subsystem can also provide a non-visual display such as audio output devices. In general, use of the term "output device" is intended to include all possible types of devices and ways to output information from computer system **5000** to the user or to another machine or computer system.

Storage subsystem **5010** stores programming and data constructs that provide the functionality of some or all of the modules and methods described herein. These software modules are generally executed by processors **5078**.

Processors **5078** can be graphics processing units (GPUs), field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and/or coarse-grained reconfigurable architectures (CGRAs). Processors **5078** can be hosted by a deep learning cloud platform such as Google Cloud Platform™, Xilinx™, and Cirrascale™. Examples of processors **5078** include Google's Tensor Processing Unit (TPU)™, rackmount solutions like GX4 Rackmount Series™, GX50 Rackmount Series™, NVIDIA DGX-1™, Microsoft™ Stratix V FPGA™, Graphcore's Intelligent Processor Unit (IPU)™, Qualcomm's Zeroth Platform™ with Snapdragon Processors™, NVIDIA's Volta™, NVIDIA's DRIVE PX™, NVIDIA's JETSON TX1/TX2 MODULE™, Intel's Nirvana™, Movidius VPU™, Fujitsu DPI™, ARM's DynamicIQ™, IBM TrueNorth™, Lambda GPU Server with Testa V100s™, and others.

Memory subsystem **5022** used in the storage subsystem **5010** can include a number of memories including a main random access memory (RAM) **5032** for storage of instructions and data during program execution and a read only memory (ROM) **5034** in which fixed instructions are stored. A file storage subsystem **5036** can provide persistent storage for program and data files, and can include a hard disk drive, a floppy disk drive along with associated removable media, a CD-ROM drive, an optical drive, or removable media cartridges. The modules implementing the functionality of certain implementations can be stored by file storage subsystem **5036** in the storage subsystem **5010**, or in other machines accessible by the processor.

Bus subsystem **5055** provides a mechanism for letting the various components and subsystems of computer system **5000** communicate with each other as intended. Although bus subsystem **5055** is shown schematically as a single bus, alternative implementations of the bus subsystem can use multiple busses.

Computer system **5000** itself can be of varying types including a personal computer, a portable computer, a workstation, a computer terminal, a network computer, a television, a mainframe, a server farm, a widely-distributed set of loosely networked computers, or any other data processing system or user device. Due to the ever-changing nature of computers and networks, the description of computer system **5000** depicted in FIG. **28** is intended only as a specific example for purposes of illustrating the preferred implementations of the present invention. Many other configurations of computer system **5000** are possible having more or less components than the computer system depicted in FIG. **28**.

It should also be noted that the different examples described herein can be combined in different ways. That is, parts of one or more examples can be combined with parts of one or more other examples. All of this is contemplated herein.

The technology disclosed can be practiced as a system, method, or article of manufacture. One or more features of an implementation can be combined with the base implementation. Implementations that are not mutually exclusive are taught to be combinable.

One or more features of an implementation can be combined with other implementations. This disclosure periodically reminds the user of these options. Omission from some implementations of recitations that repeat these options should not be taken as limiting the combinations taught in the preceding sections—these recitations are hereby incorporated forward by reference into each of the following implementations.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A computer-implemented method for analyzing data posture in a cloud environment, the computer-implemented method comprising:

receiving a request to analyze a data posture of a database in the cloud environment, wherein the database includes a user access credential configured to provide user access to the database;

in response to the request to analyze the data posture of the database, identifying a location of a snapshot of the database, and accessing, using a cloud environment role corresponding to the cloud environment, the location of the snapshot;

performing data posture analysis using data of the snapshot to obtain an indication of a structure of schema objects in the database; and

generating a representation of a user interface display that represents the data posture of the database based on the data posture analysis performed on data of the snapshot.

2. The computer-implemented method of claim **1**, wherein

the database comprises a first database,

the snapshot comprises a first snapshot of the first database,

the user access credential comprises a first user access credential, and

the computer-implemented method further comprises:

receiving a request to analyze a data posture of a second database in the cloud environment, wherein the second database includes a second user access credential configured to provide user access to the second database;

accessing, using the cloud environment role, a location of a second snapshot of the second database; and

performing data posture analysis using data of the second snapshot to obtain an indication of a structure of schema objects in the second database.

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

tracing network communication paths between pairs of compute resources in the cloud environment and storage resources corresponding to the database;

qualifying a subset of the pairs of the compute resources and the storage resources as vulnerable to breach attack based on the data posture analysis; and

generating a representation of propagation of the breach attack along the network communication paths, the representation of propagation of the breach attack identifying relationships between the subset of the pairs of the compute resources and the storage resources.

4. The computer-implemented method of claim **2**, and further comprising:

discovering the first and second snapshots using a cloud provider application programming interface (API); and

accessing each of the first and second snapshots through the cloud provider API.

5. The computer-implemented method of claim **2**, wherein performing the data posture analysis comprises:

obtaining metadata representing a structure of schema objects in at least one of the first database or the second database; and

based on the metadata, executing a content-based data classifier to classify data items in the schema objects.

6. The computer-implemented method of claim **5**, and further comprising:

based on the metadata, executing a content-based data classifier that analyzes content of data items in the schema objects by comparing the data items to predefined target data profiles and generates a classifier result that classifies the data items based on the content.

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

wherein performing the data posture analysis using data of the snapshot comprises:

generating a separate representation of the first database, that is separate from the database, using the snapshot, and

scanning the representation of the first database.

8. The computer-implemented method of claim **2**, wherein the first and second snapshots comprise read-only point-in-time copies of the first and second databases, respectively.

9. The computer-implemented method of claim **7**, wherein

the database is stored on a first server in the cloud environment,

generating the separate representation of the database comprises recreating the database on a second server using the snapshot, and

scanning the separate representation of the database comprises scanning the recreated database on the second server.

10. The computer-implemented method of claim **1**, wherein the user access credential comprises secret data corresponding to a user associated with the database, and the cloud environment role comprises a cloud provider role, and the snapshot comprise a read-only point-in-time copy of the database.

11. A computing system comprising:

at least one processor; and

memory storing instructions executable by the at least one processor, wherein the instructions, when executed, cause the computing system to:

receive a request to analyze a data posture of a database in a cloud environment, wherein the database includes a user access credential configured to provide user access to the database;

in response to the request to analyze the data posture of the database,

perform data posture analysis on a representation that is separate from the database, wherein the data posture analysis is configured to:

access, using a cloud environment role corresponding to the cloud environment, a snapshot of the database;

obtain the representation based on the snapshot; and

identify a structure of schema objects in the database based on the representation; and

generate a representation of a user interface display that represents the data posture of the database based on the identified structure of schema objects.

12. The computing system of claim **11**, wherein

the database comprises a first database,

the snapshot comprises a first snapshot of the first database,

the user access credential comprises a first user access credential, and

the instructions, when executed, cause the computing system to:

receive a request to analyze a data posture of a second database in the cloud environment, wherein the second database includes a second user access credential configured to provide user access to the second database;

access, using the cloud environment role, a location of a second snapshot of the second database; and perform data posture analysis using data of the second snapshot to obtain an indication of a structure of schema objects in the second database.

13. The computing system of claim **12**, wherein the instructions, when executed, cause the computing system to:

discover the first and second snapshots using a cloud provider application programming interface (API); and

access each of the first and second snapshots through the cloud provider API.

14. The computing system of claim **12**, wherein the instructions, when executed, cause the computing system to:

obtain metadata representing a structure of schema objects in at least one of the first database or the second database; and

based on the metadata, execute a content-based data classifier to classify data items in the schema objects.

15. The computing system of claim **14**, wherein the instructions, when executed, cause the computing system to:

based on the metadata, execute a content-based data classifier that analyzes content of data items in the schema objects by comparing the data items to pre-defined target data profiles and generates a classifier result that classifies the data items based on the content.

16. The computing system of claim **11**, wherein the instructions, when executed, cause the computing system to:

generate a separate representation of the database, that is separate from the database, using the snapshot, and

perform the data posture analysis based on a scan of the separate representation of the database.

17. The computing system of claim **11**, wherein the snapshot comprises a read-only point-in-time copy of the database.

18. The computing system of claim **11**, wherein the database is deployed in a production environment and configured to receive a user request for a data manipulation operation on data stored in the database.

19. The computing system of claim **14**, wherein the schema objects comprise at least one data column within a table, and the data items comprise a plurality of cells within the at least one data column.

20. A computing system comprising:

at least one processor; and

memory storing instructions executable by the at least one processor, wherein the instructions, when executed, provide:

a cloud data analysis logic configured to:

receive a request to perform data posture analysis on a database in a cloud environment, wherein the database includes a user access credential;

in response to the request, access, through a cloud provider application programming interface (API) using a cloud provider role corresponding to the cloud environment, a snapshot of the database; and

generate a separate database representation of the database, that separate is from the database, using the snapshot;

a scanner configured to scan the separate database representation of the database to obtain a representation of a structure of schema objects; and

a user interface component configured to generate a representation of a user interface display that represents the data posture analysis based on the scan.

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