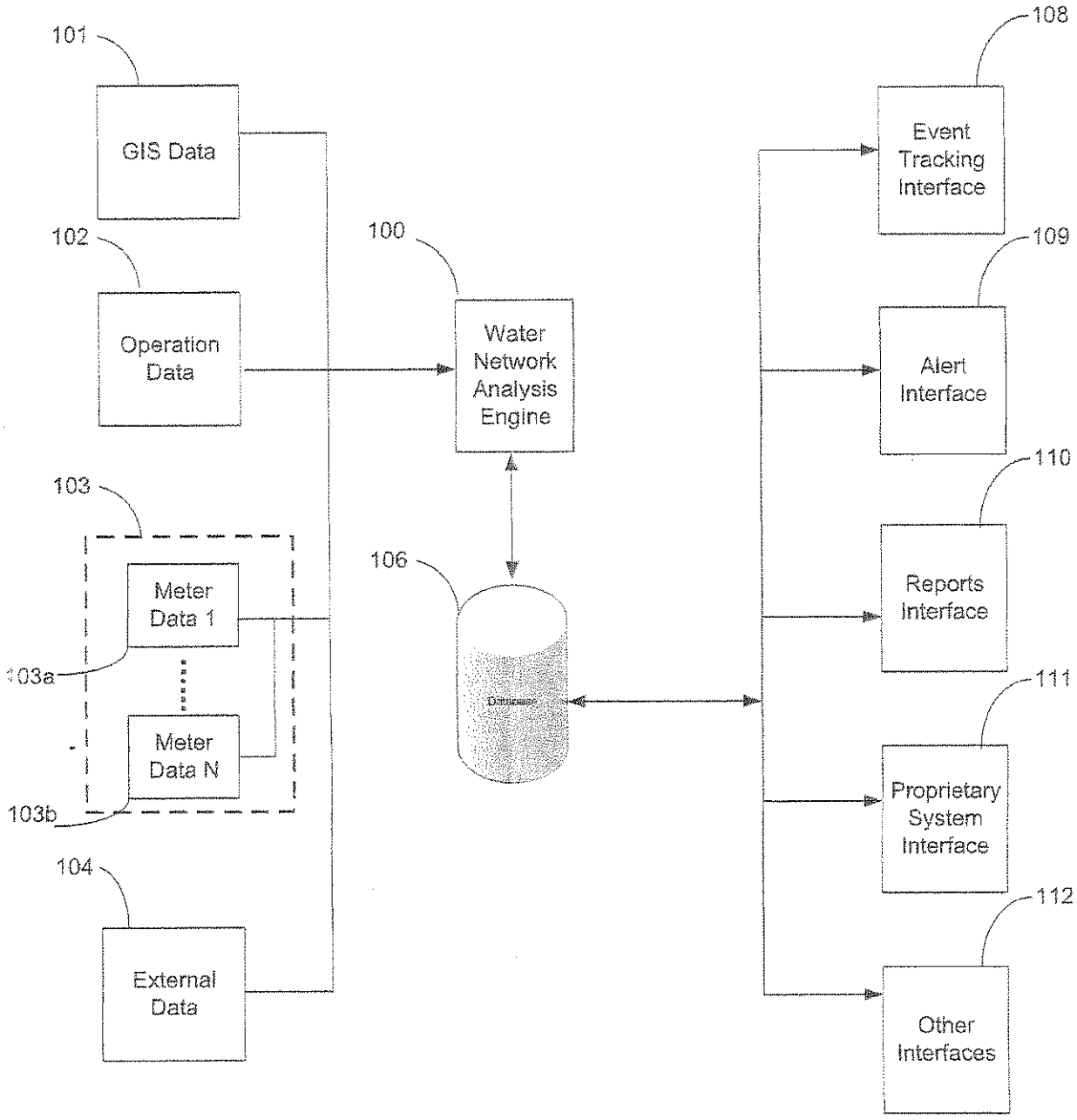
101
GIS Data
102
Operation Data
103
Meter Data 1
103a
Meter Data N
103b
104
External Data
100
Water Network Analysis Engine
106
Database
108
Event Tracking Interface
109
Alert Interface
110
Reports Interface
111
Proprietary System Interface
112
Other Interfaces

Fig. 1

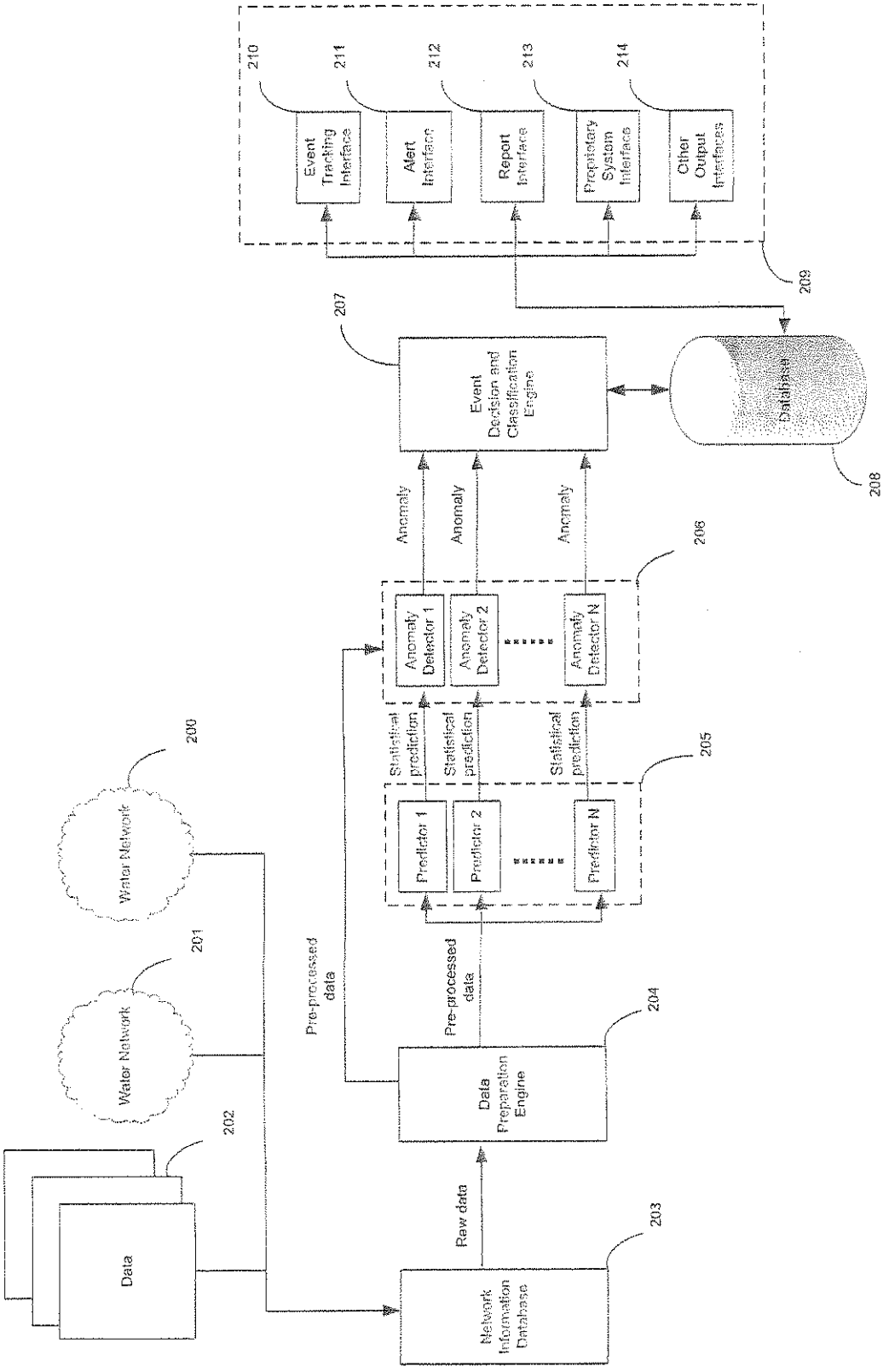
Data
Water Network
Water Network
Network Information Database
Raw data
Data Preparation Engine
Pre-processed data
Pre-processed data
Predictor 1
Predictor 2
Predictor N
Statistical prediction
Statistical prediction
Statistical prediction
Anomaly Detector 1
Anomaly Detector 2
Anomaly Detector N
Anomaly
Anomaly
Anomaly
Event Decision and Classification Engine
Database
Event Tracking Interface
Alert Interface
Report Interface
Proprietary System Interface
Other Output Interfaces
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214

Fig. 2

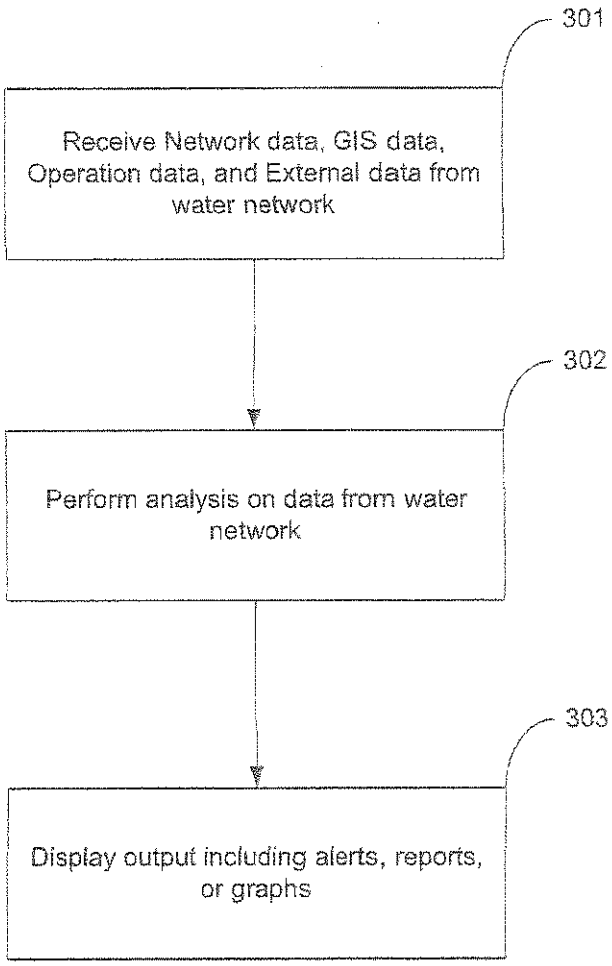
301
Receive Network data, GIS data, Operation data, and External data from water network
302
Perform analysis on data from water network
303
Display output including alerts, reports, or graphs

Fig. 3

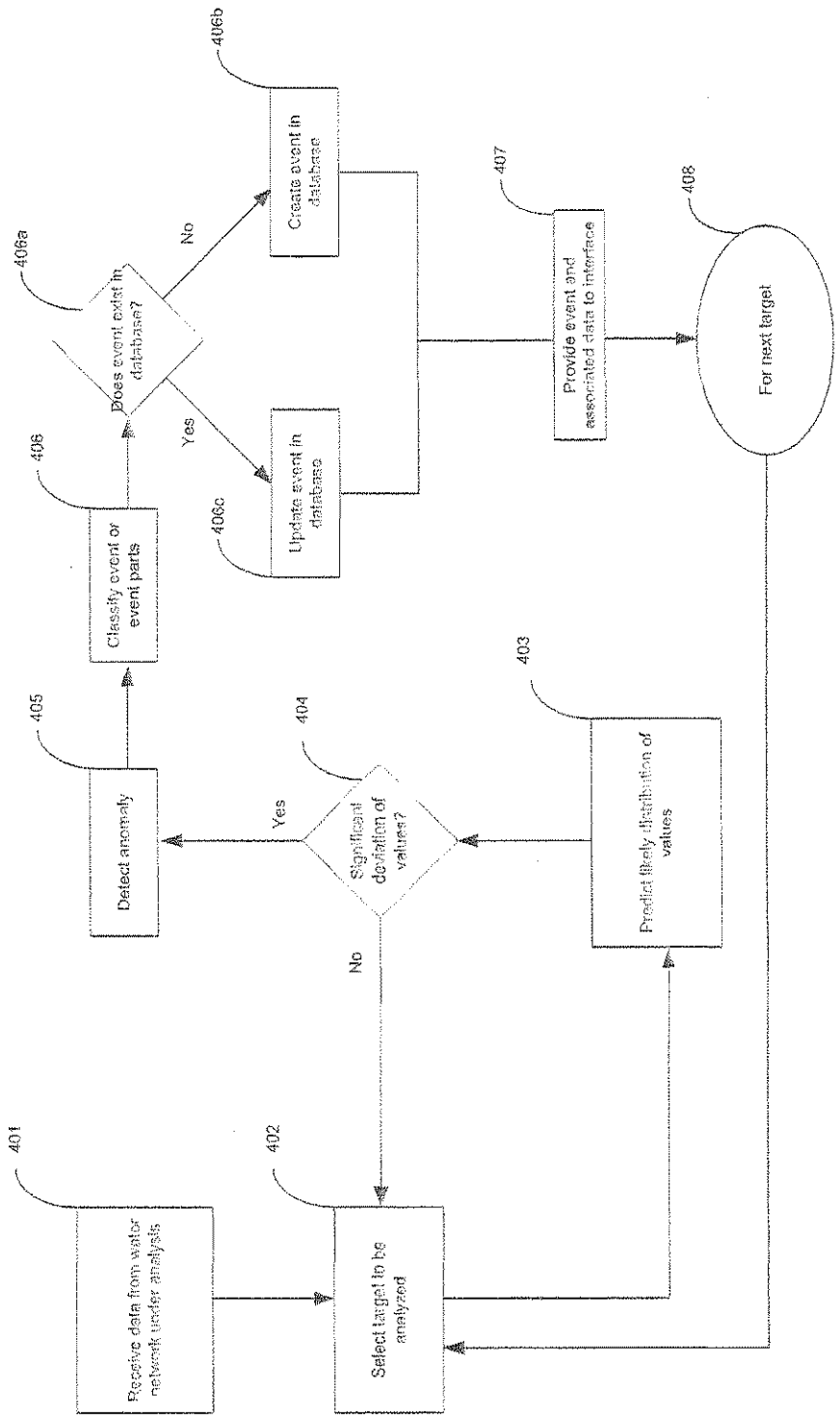
401
Receive data from water network under analysis
402
Select target to be analyzed
403
Predict likely distribution of values
404
Significant deviation of values?
Yes
No
405
Detect anomaly
406
Classify event or event parts
406a
Does event exist in database?
Yes
No
406b
Create event in database
406c
Update event in database
407
Provide event and associated data to interface
408
For next target

Fig. 4

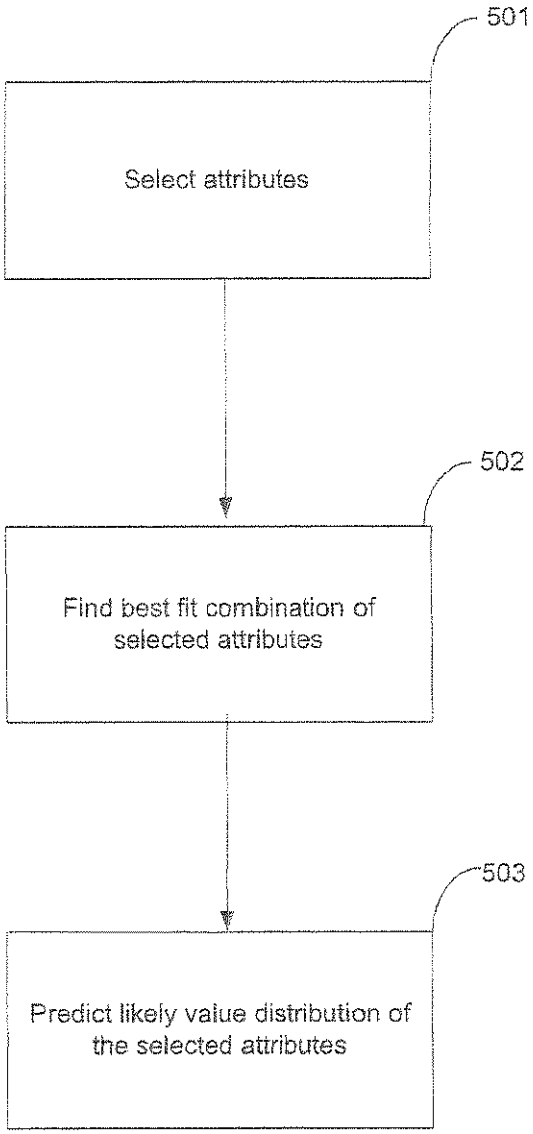
501
Select attributes
502
Find best fit combination of selected attributes
503
Predict likely value distribution of the selected attributes

Fig. 5

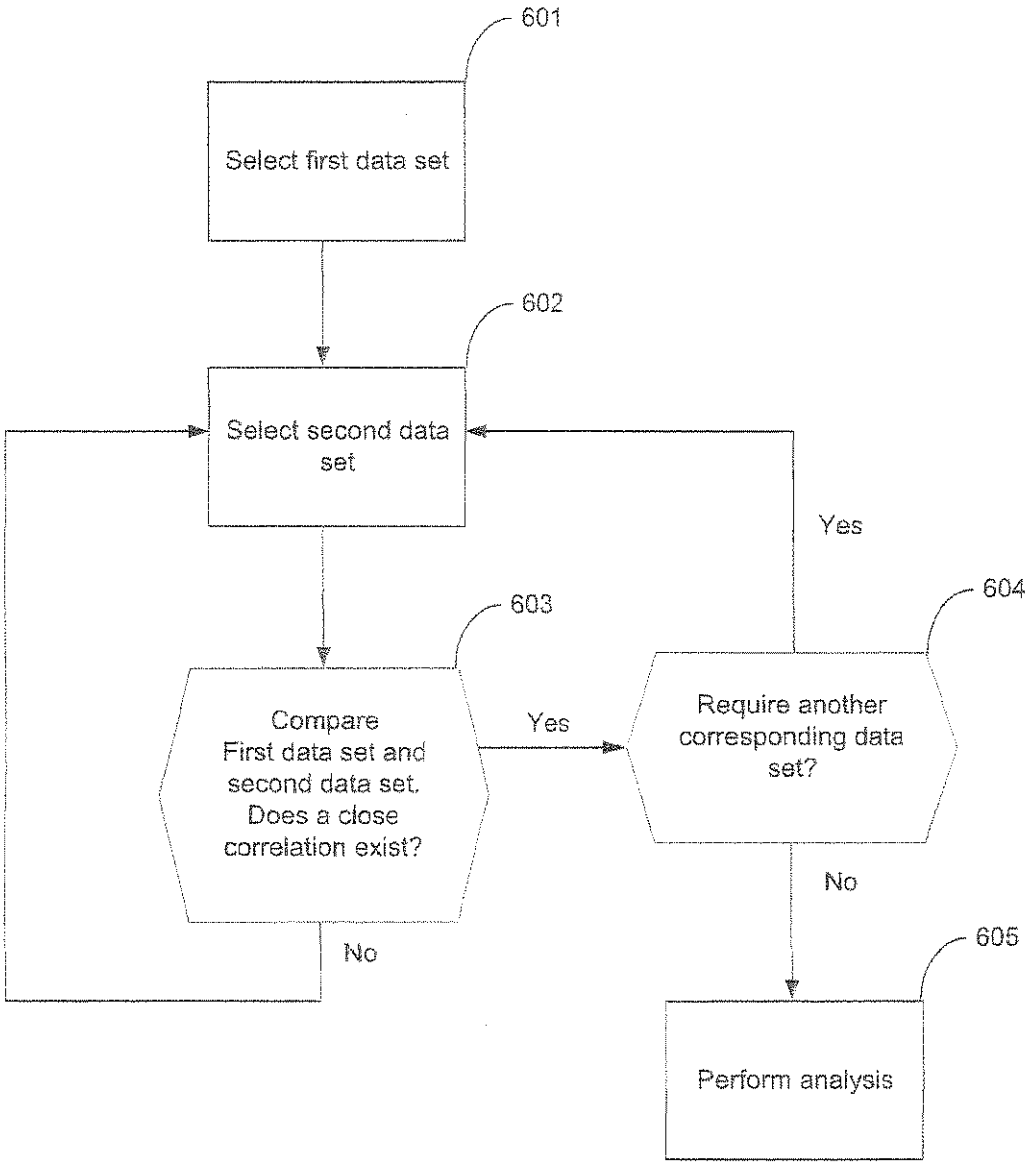
601
Select first data set
602
Select second data set
603
Compare First data set and second data set. Does a close correlation exist?
Yes
No
604
Require another corresponding data set?
Yes
No
605
Perform analysis

Fig. 6

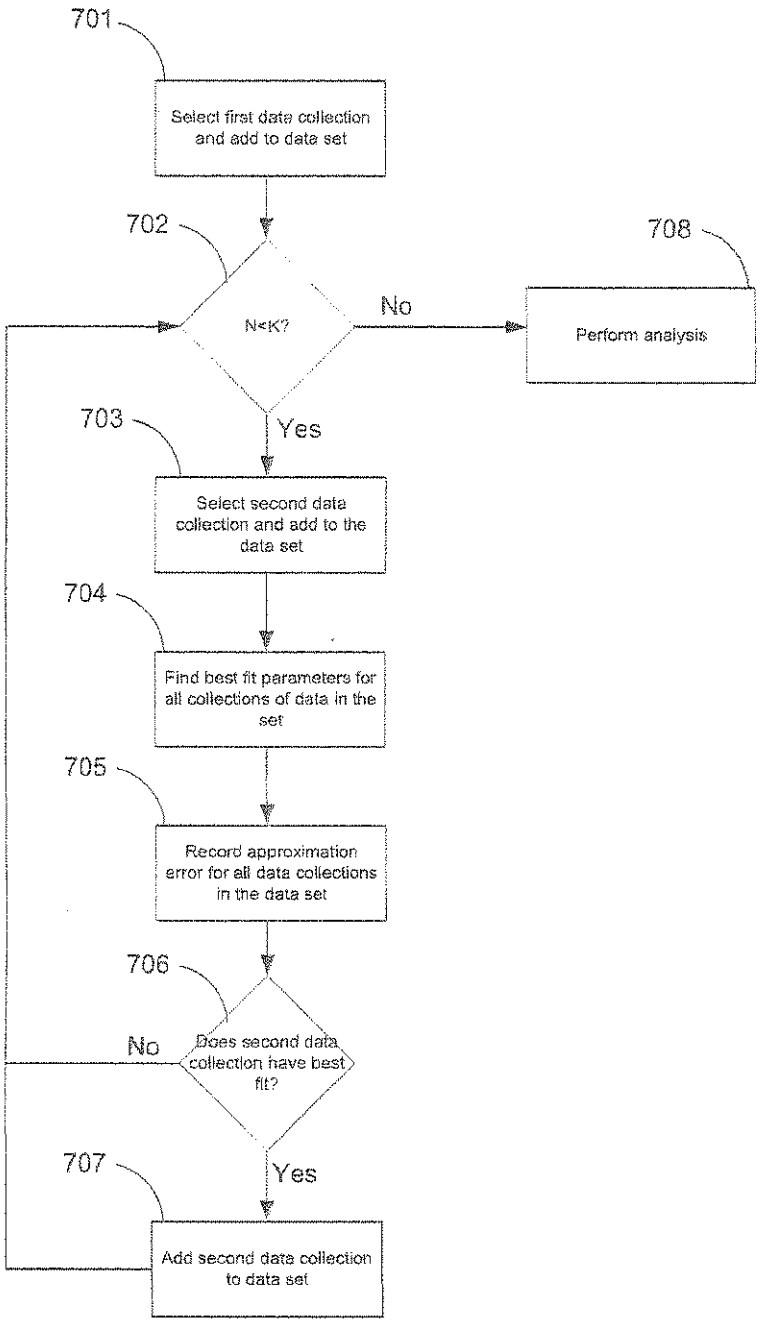
701
Select first data collection and add to data set
702
N<K?
No
708
Perform analysis
Yes
703
Select second data collection and add to the data set
704
Find best fit parameters for all collections of data in the set
705
Record approximation error for all data collections in the data set
706
Does second data collection have best fit?
No
Yes
707
Add second data collection to data set

Fig. 7

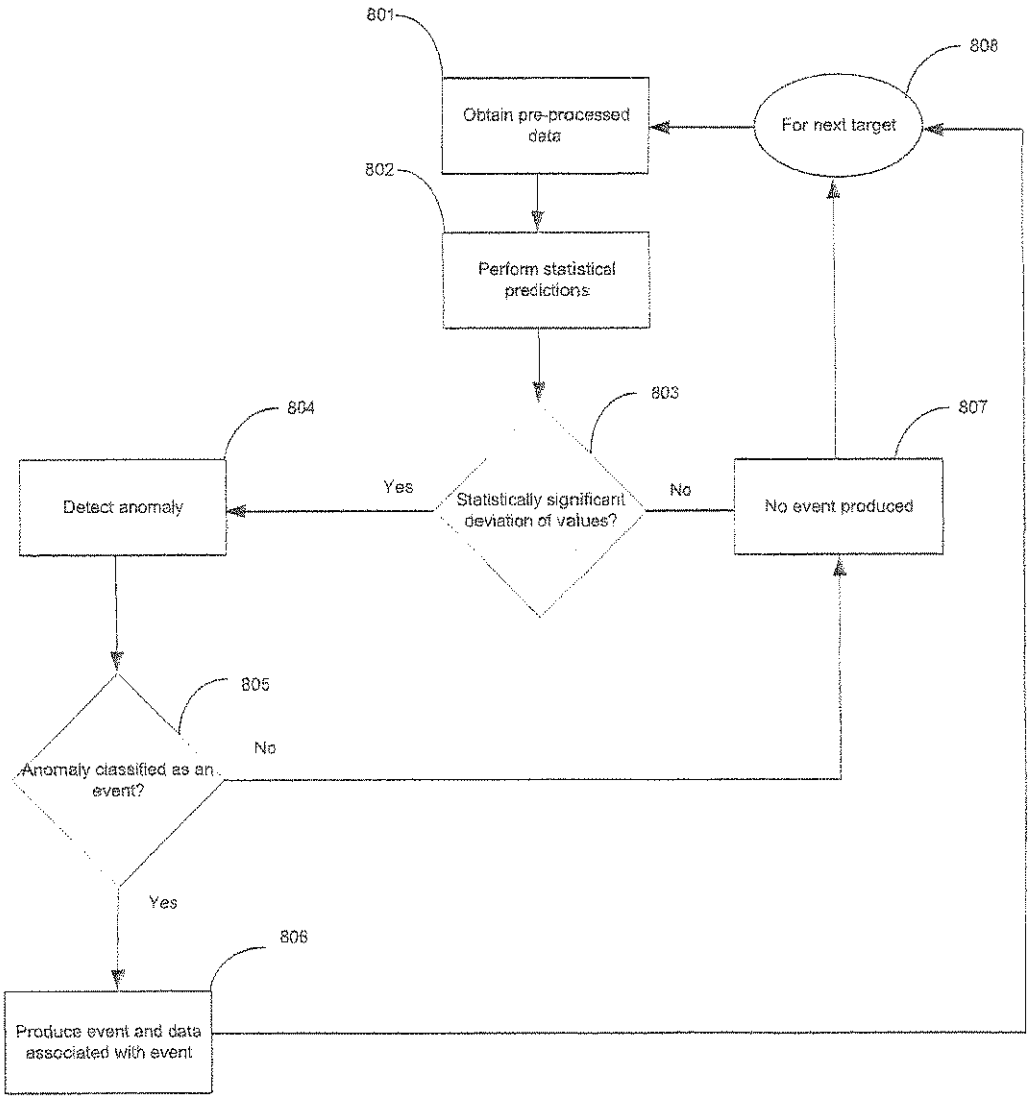
801
Obtain pre-processed data
808
For next target
802
Perform statistical predictions
803
Statistically significant deviation of values?
Yes
No
804
Detect anomaly
807
No event produced
805
Anomaly classified as an event?
No
Yes
806
Produce event and data associated with event

Fig. 8

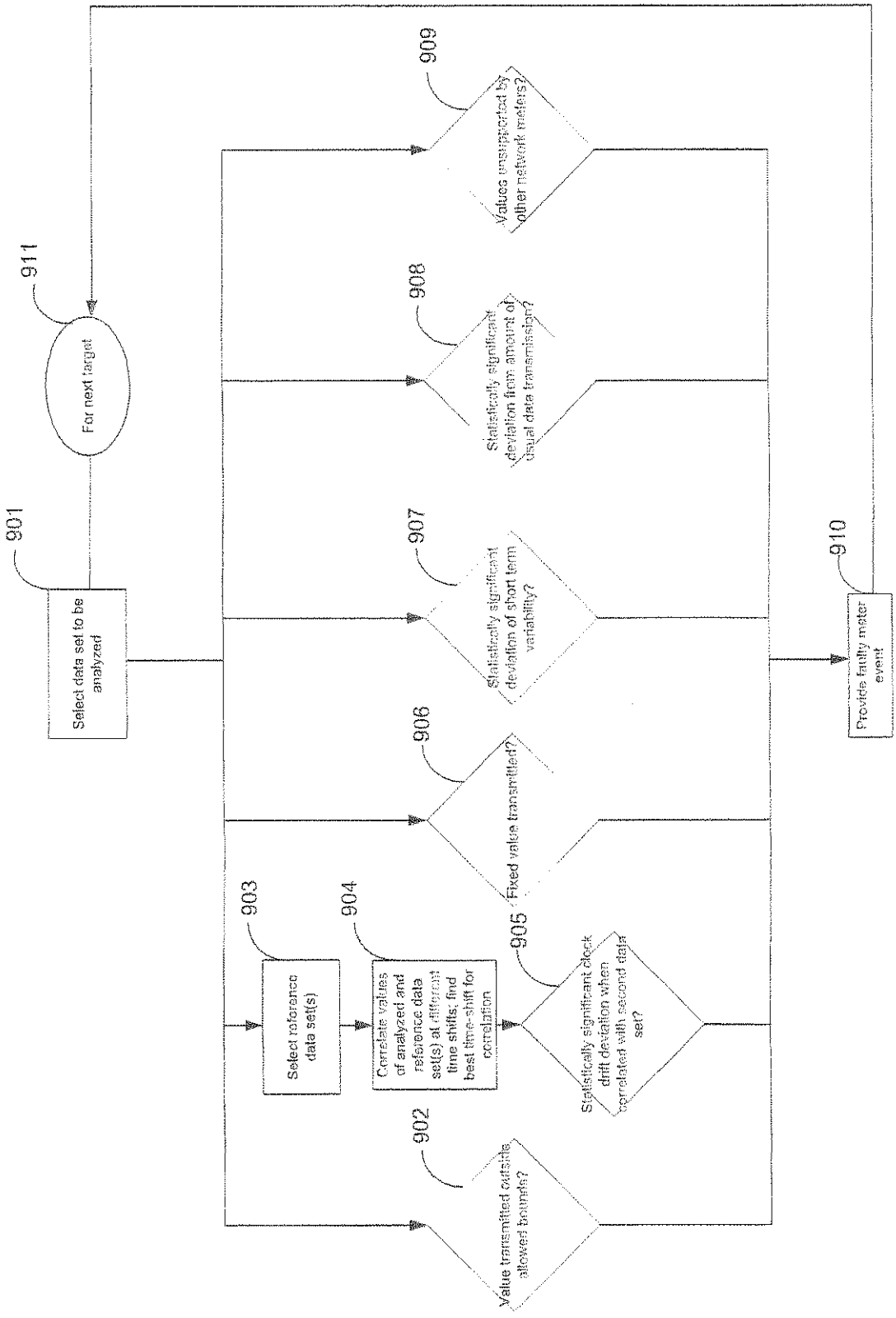
911
For next target
901
Select data set to be analyzed
902
Value transmitted outside allowed bounds?
903
Select reference data set(s)
904
Correlate values of analyzed and reference data set(s) at different time shifts; find best time-shift for correlation
905
Statistically significant clock drift deviation when correlated with second data set?
906
Fixed value transmitted?
907
Statistically significant deviation of short term variability?
908
Statistically significant deviation from amount of usual data transmission?
909
Values unsupported by other network meters?
910
Provide faulty meter event

Fig. 9

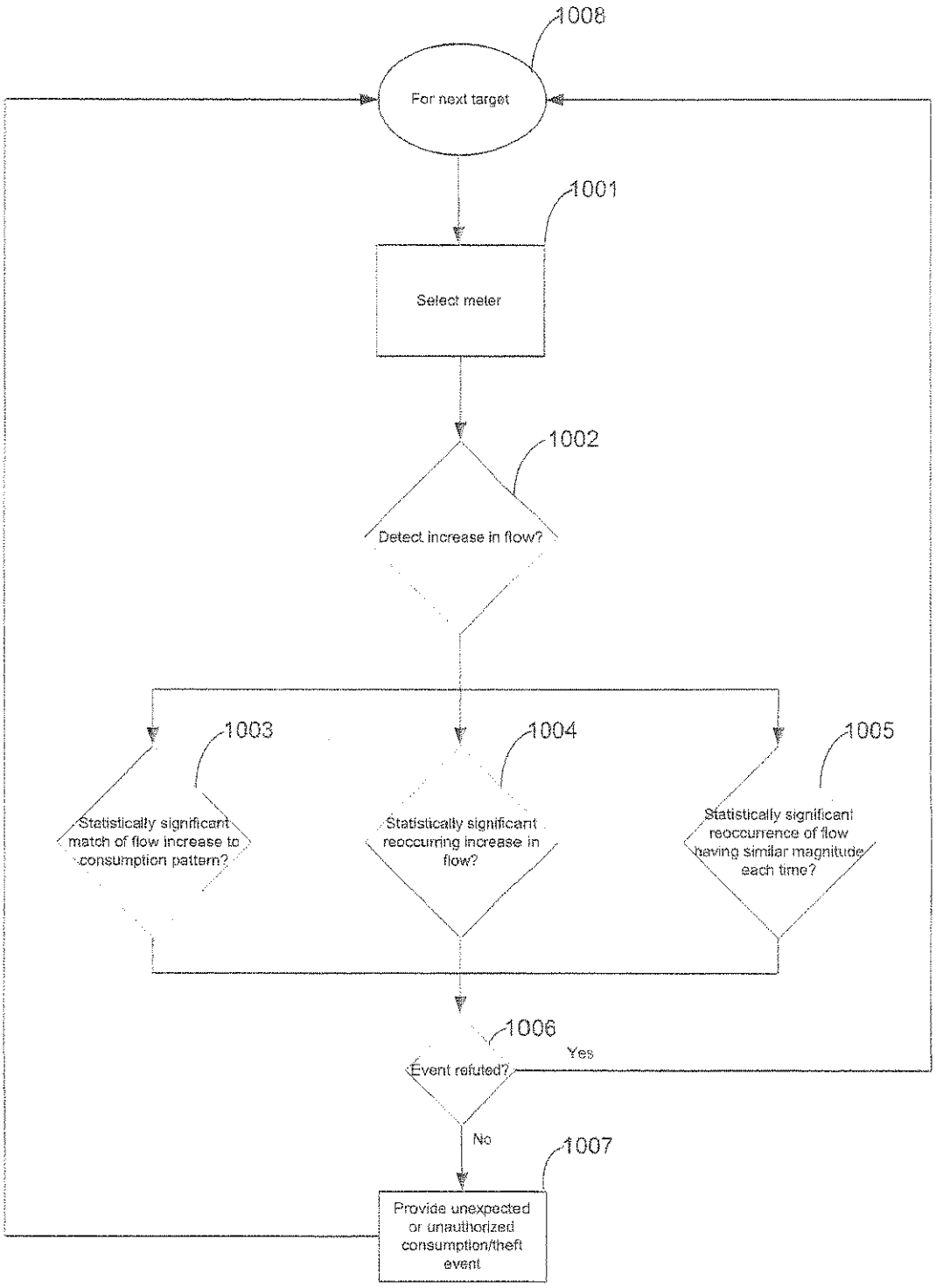
1008
For next target
1001
Select meter
1002
Detect increase in flow?
1003
Statistically significant match of flow increase to consumption pattern?
1004
Statistically significant reoccurring increase in flow?
1005
Statistically significant reoccurrence of flow having similar magnitude each time?
1006
Event refuted?
Yes
No
1007
Provide unexpected or unauthorized consumption/theft event

Fig. 10

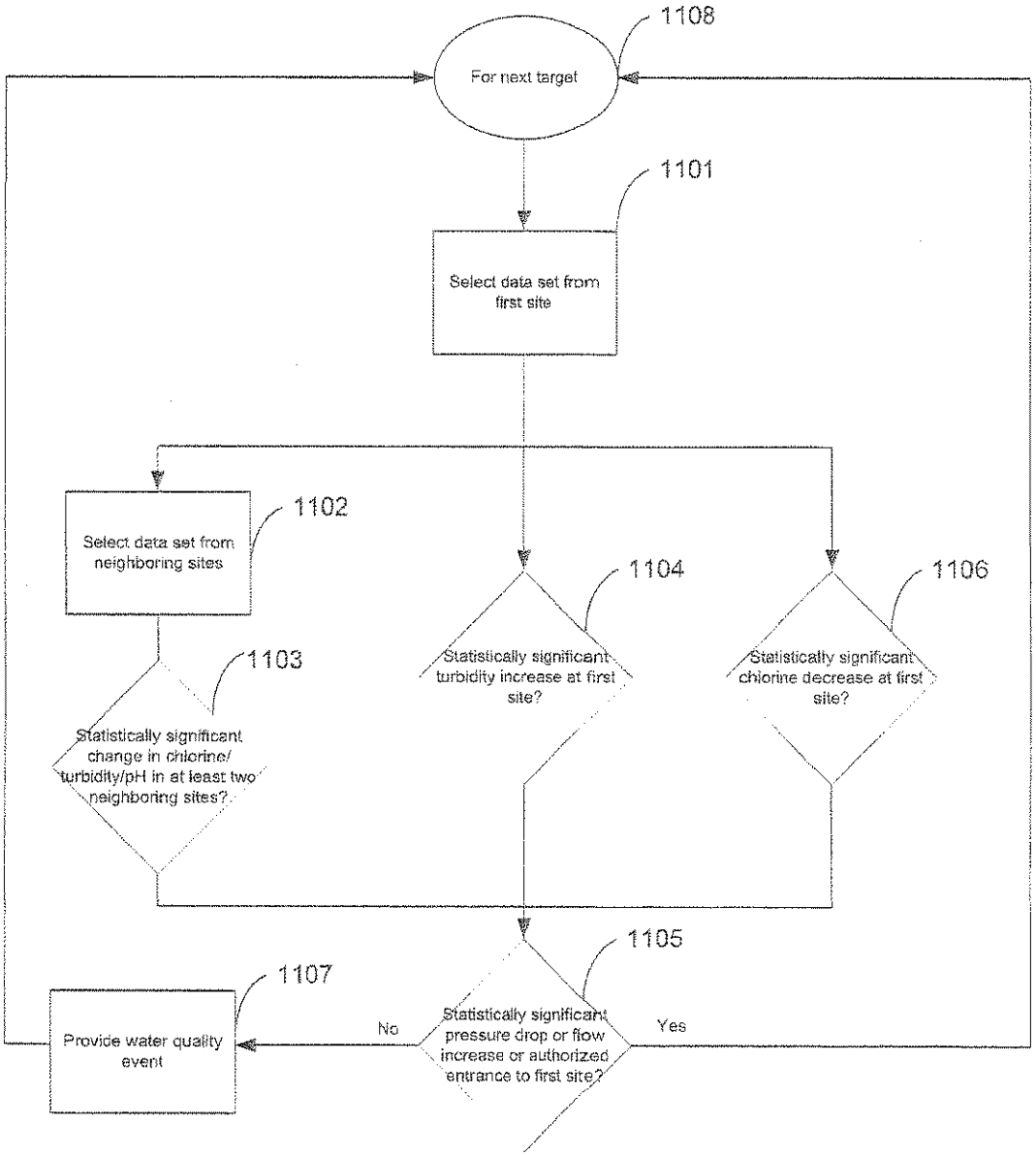
1108
For next target
1101
Select data set from first site
1102
Select data set from neighboring sites
1103
Statistically significant change in chlorine/ turbidity/pH in at least two neighboring sites?
1104
Statistically significant turbidity increase at first site?
1106
Statistically significant chlorine decrease at first site?
1105
Statistically significant pressure drop or flow increase or authorized entrance to first site?
No
Yes
1107
Provide water quality event

Fig. 11

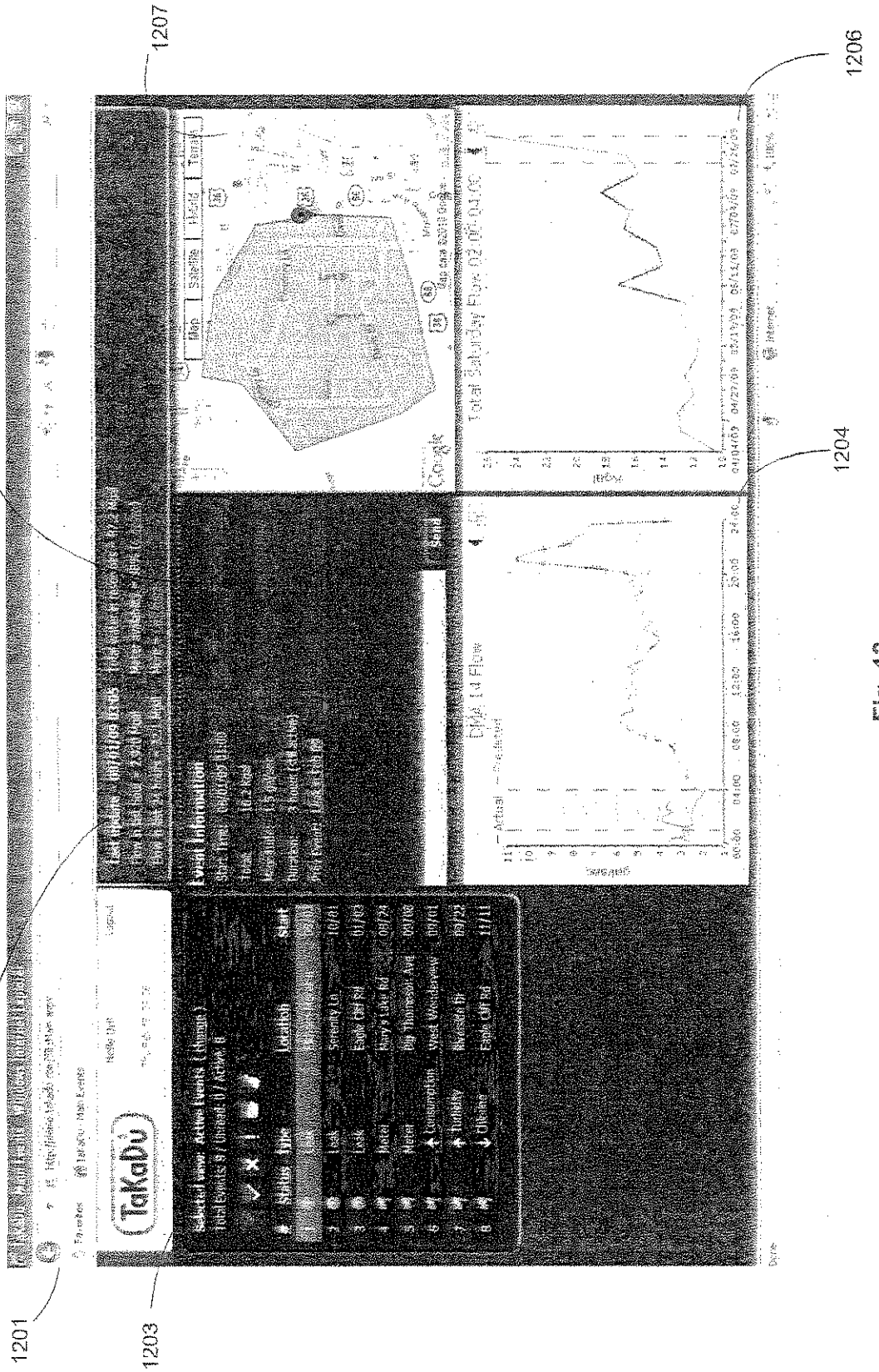

Fig. 12

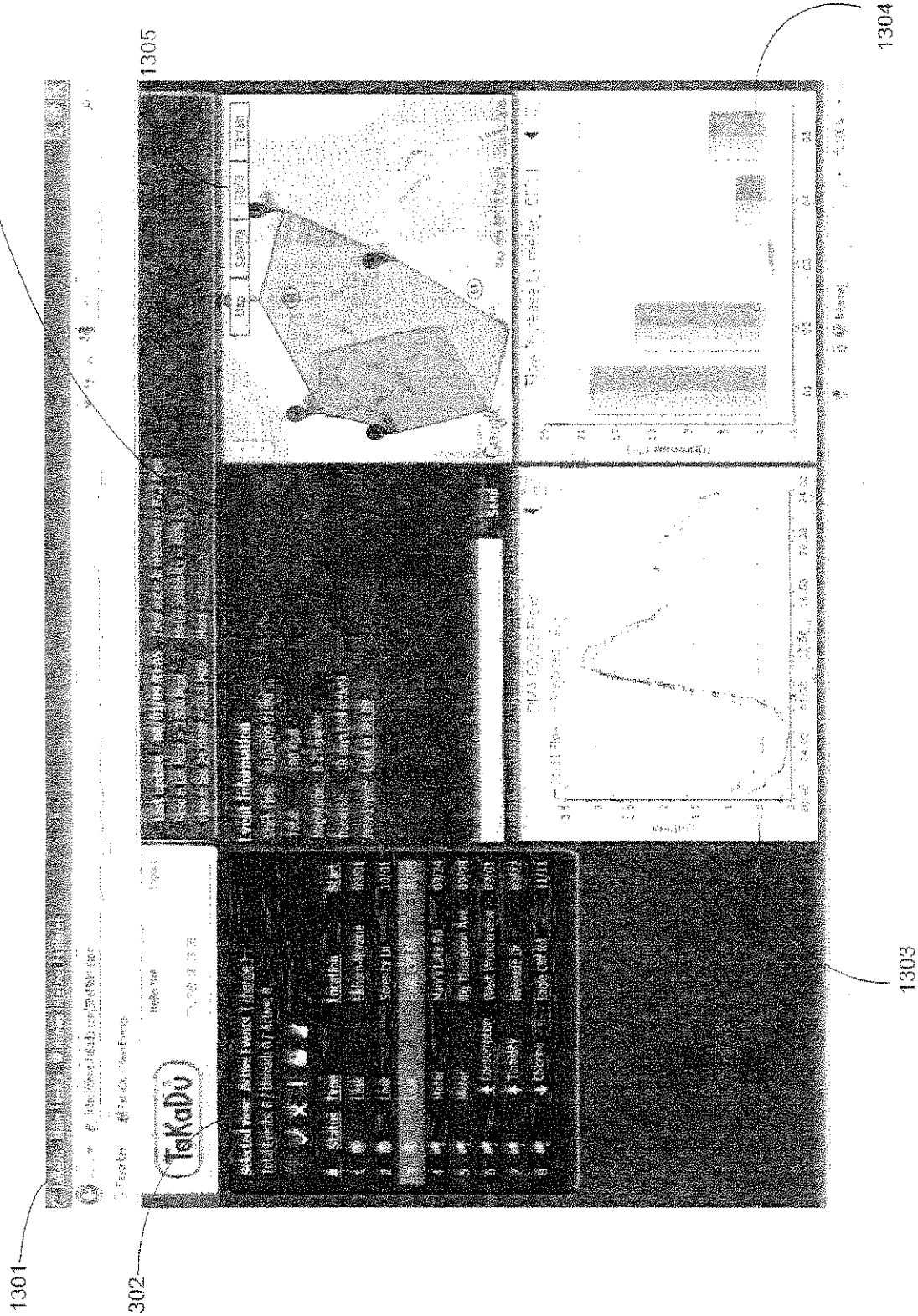

Fig. 13

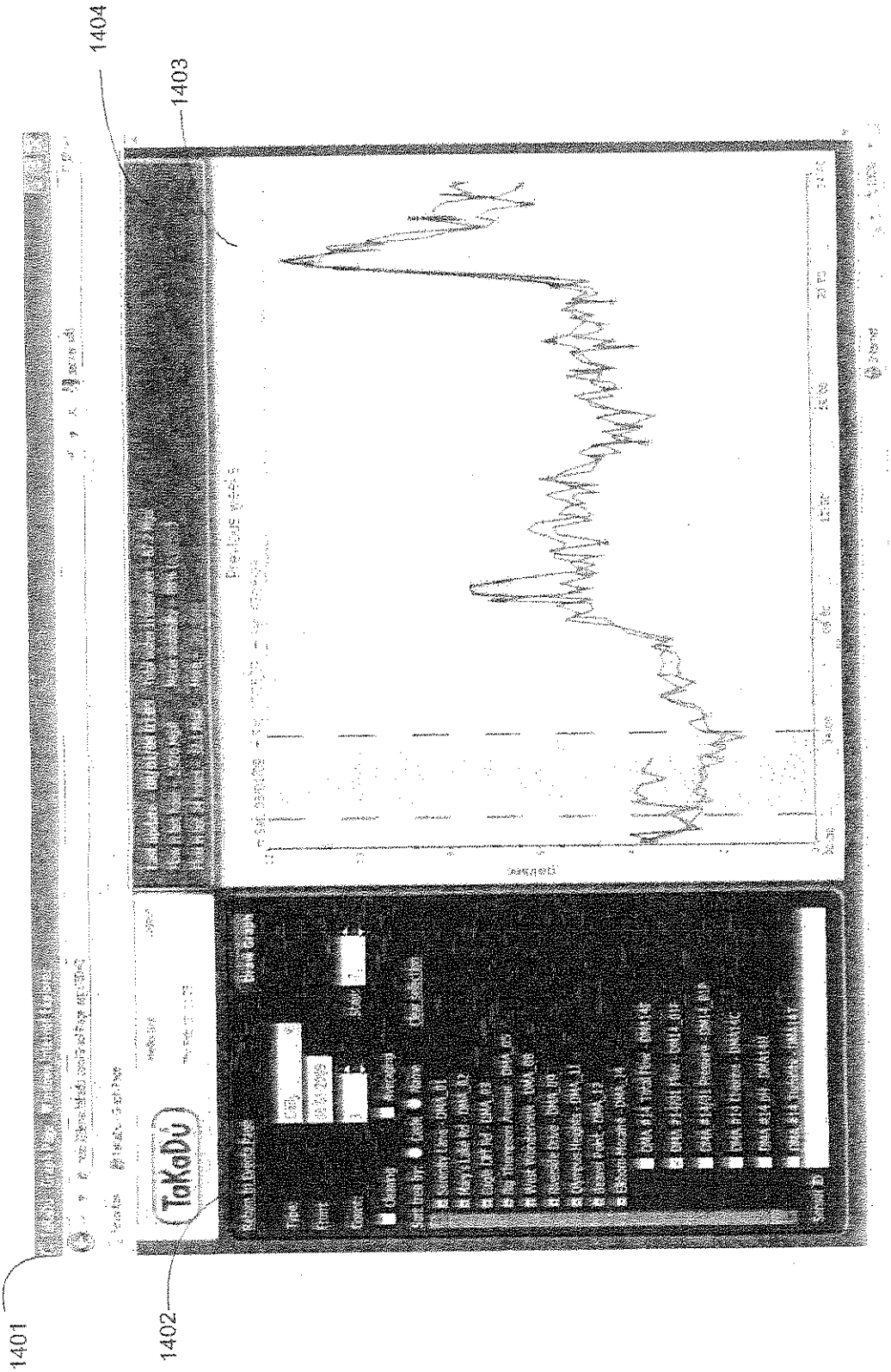

Fig. 14

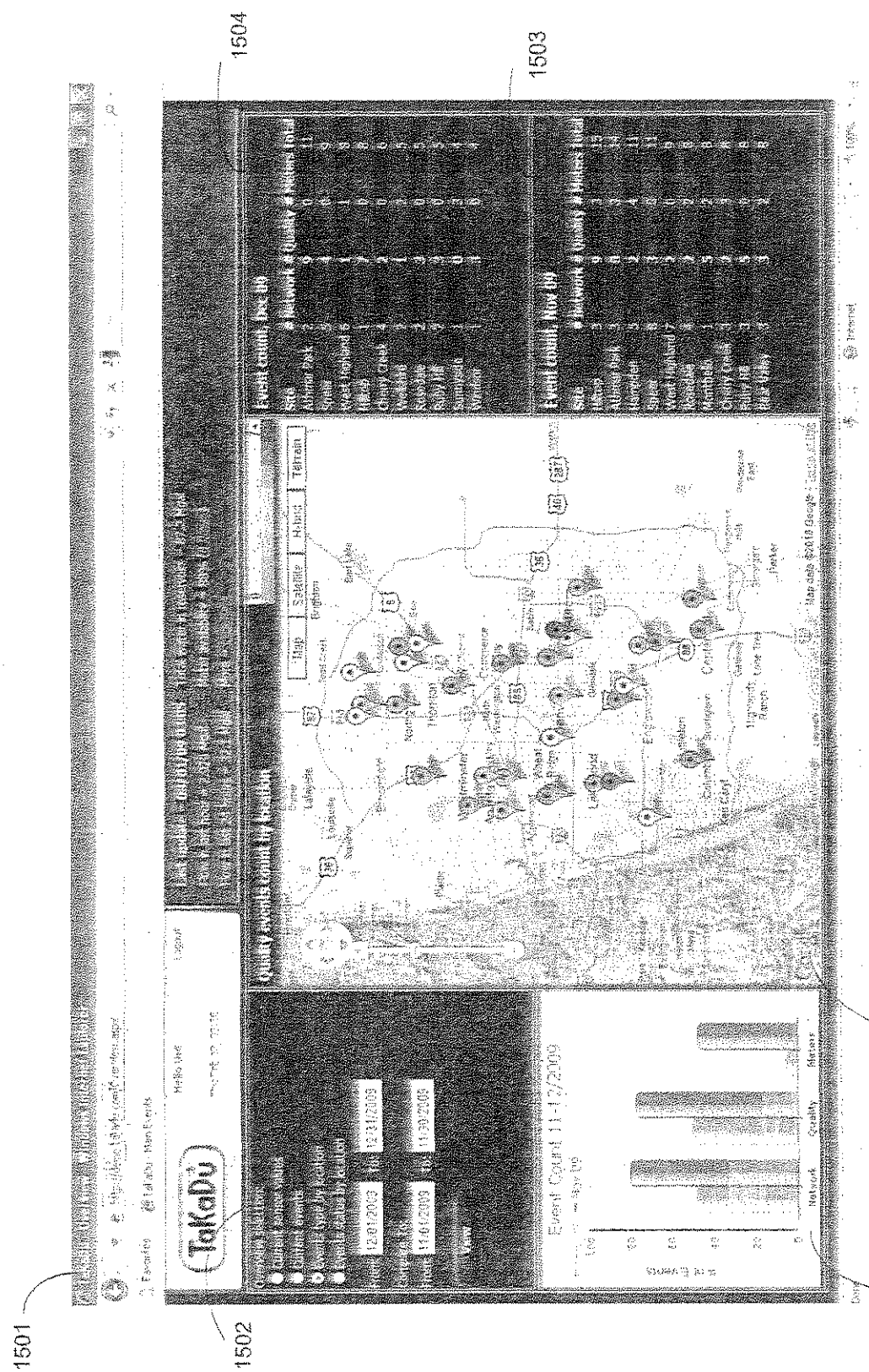

Fig. 15