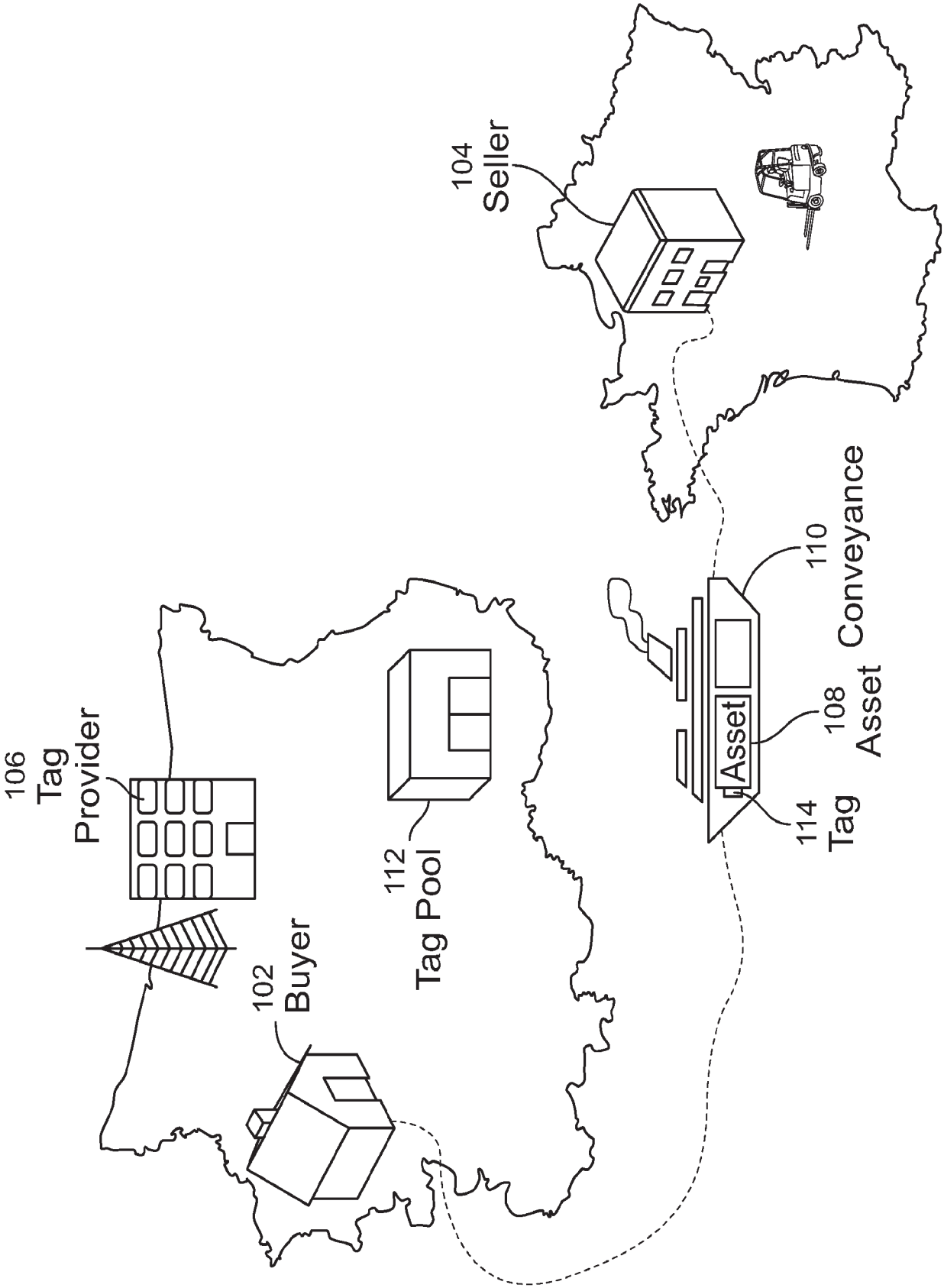

104
Seller
110
Conveyance
108
Asset
Asset
114
Tag
112
Tag Pool
106
Tag
Provider
102
Buyer

FIG. 1

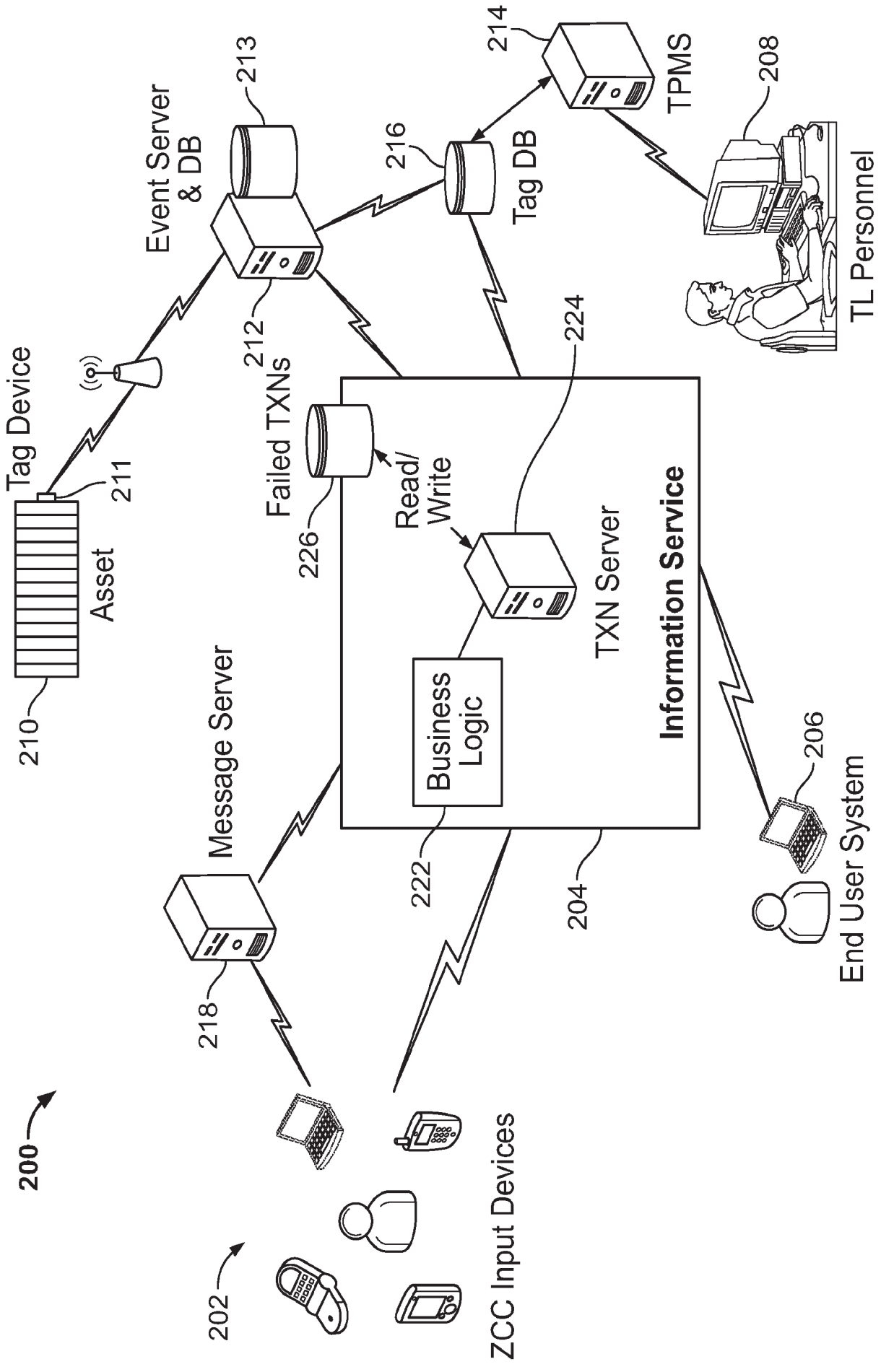

200
202
ZCC Input Devices
218
Message Server
210
Asset
211
Tag Device
212
Event Server & DB
213
214
TPMS
208
TL Personnel
216
Tag DB
226
Failed TXNs
Read/ Write
224
TXN Server
Information Service
Business Logic
222
204
206
End User System

FIG. 2

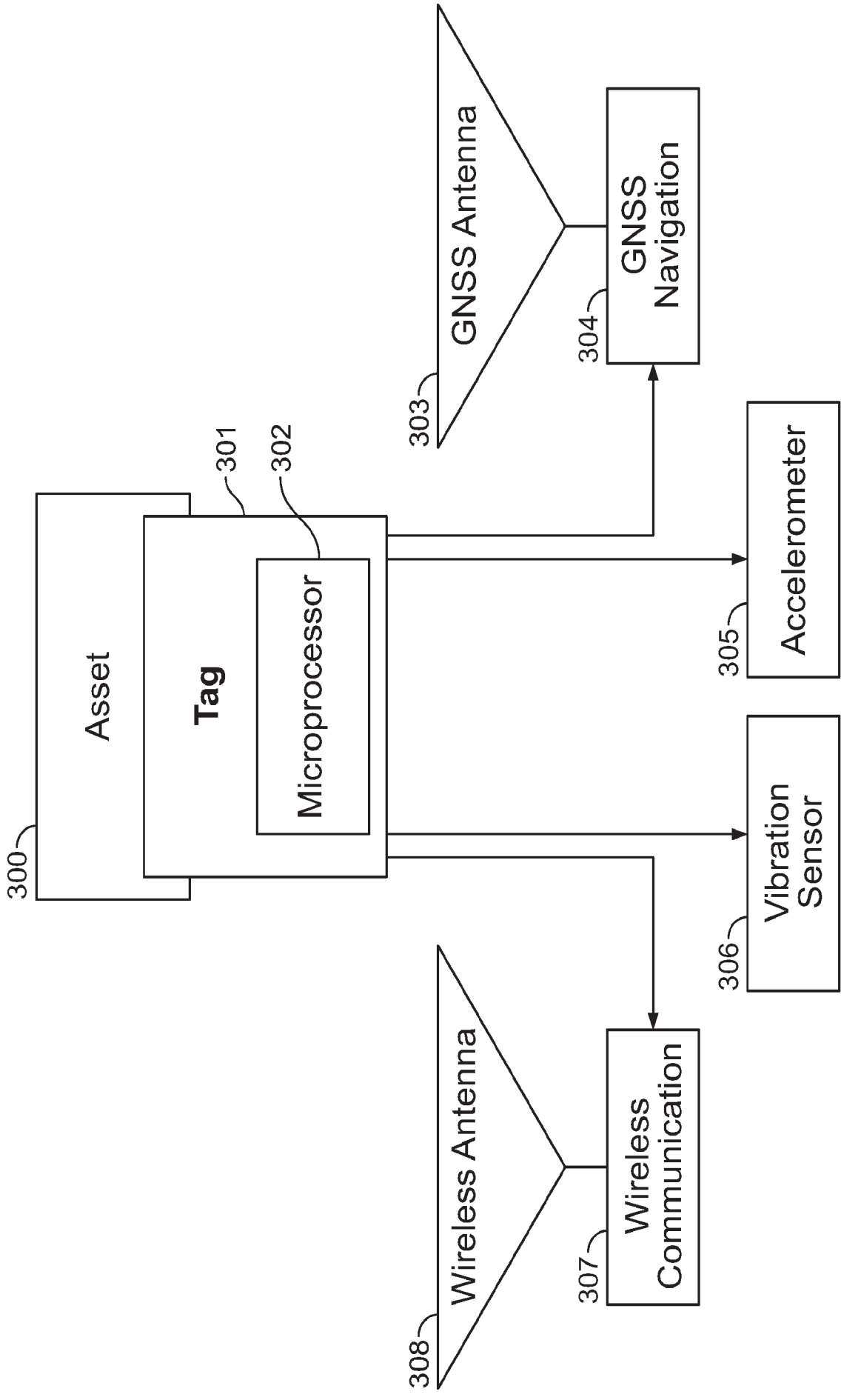

Asset
Tag
Microprocessor
300
301
302
GNSS Antenna
303
GNSS Navigation
304
Accelerometer
305
Vibration Sensor
306
Wireless Communication
307
Wireless Antenna
308

FIG. 3

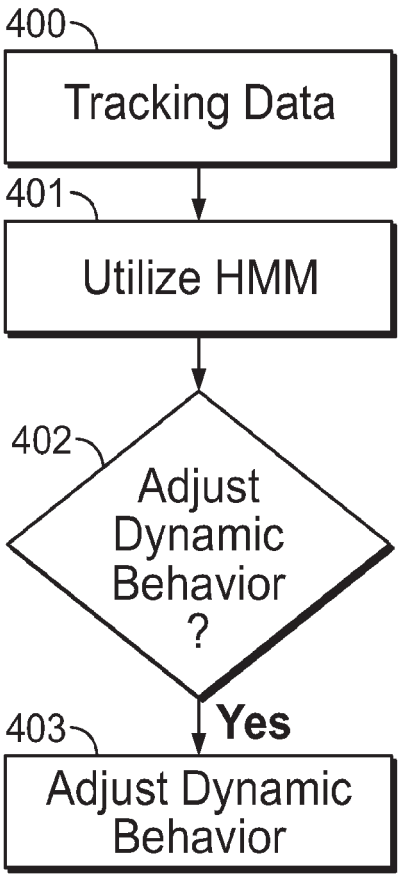

400
Tracking Data
401
Utilize HMM
402
Adjust Dynamic Behavior ?
Yes
403
Adjust Dynamic Behavior

FIG. 4

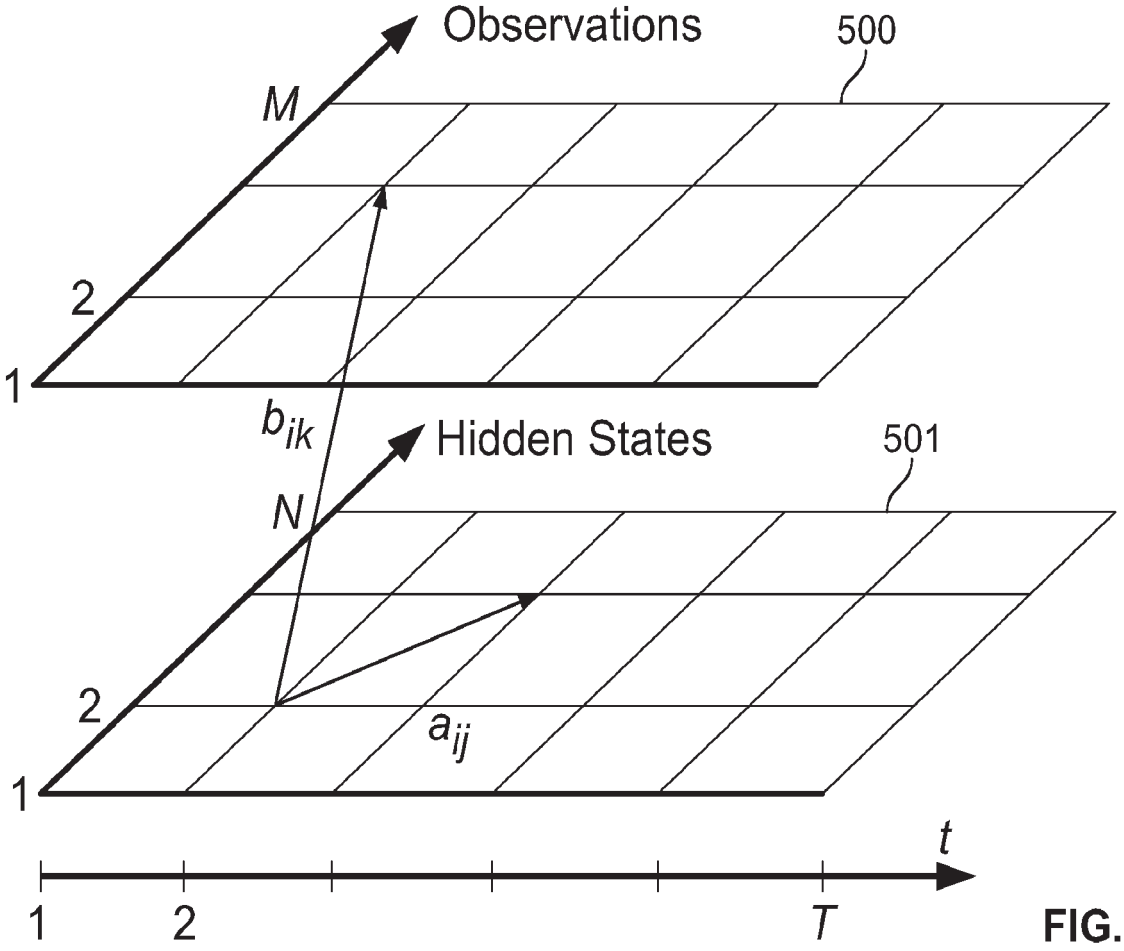

Observations
500
M
2
1
b_{ik}
Hidden States
501
N
2
1
a_{ij}
t
1
2
T

FIG. 5

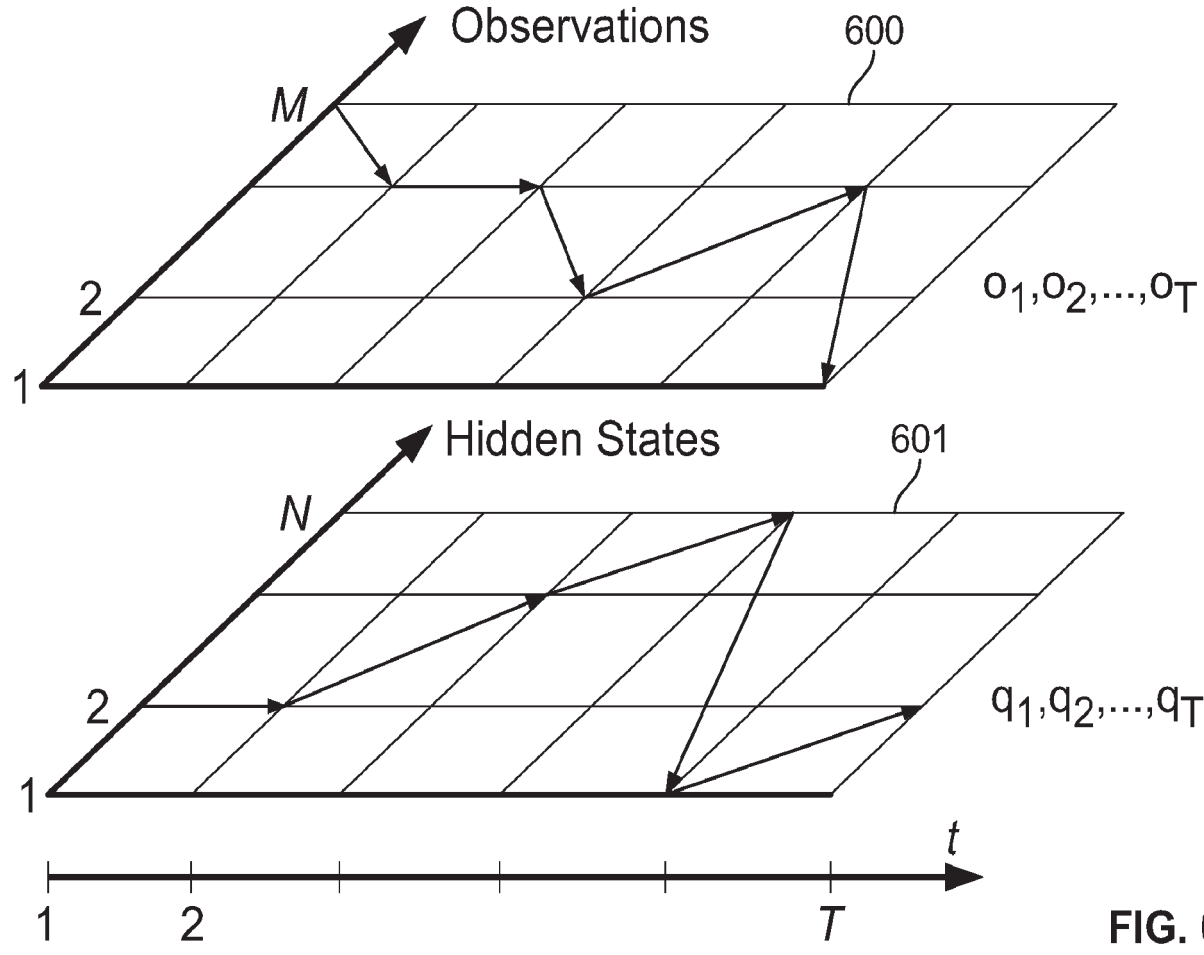

Observations
600
M
2
1
$o_1,o_2,...,o_T$
Hidden States
601
N
2
1
$q_1,q_2,...,q_T$
t
1
2
T

FIG. 6

```
ForwardBackward(guessState, sequenceIndex):
    if sequenceIndex is past the end of the sequence, return 1
    if (guessState, sequenceIndex) has been seen before, return saved result
    result = 0
    for each neighboring state n:
        result = result + (transition probability from guessState to n given observation
element at sequenceIndex)*ForwardBackward(n, sequenceIndex+1)
    save result for (guessState, sequenceIndex)
    return result
```

FIG. 7

1) Initialization:

800

$$\delta_1(i) = \pi_i b_i(o_1), \quad 1 \le i \le N$$

$$\psi_1(i) = 0.$$

2) Recursion:

801

$$\delta_t(j) = \max_{1 \le i \le N} [\delta_{t-1}(i) a_{ij}] b_j(o_t), \quad 2 \le t \le T, \quad 1 \le j \le T$$

$$\psi_t(j) = \operatorname{argmax}_{1 \le i \le N} [\delta_{t-1}(i) a_{ij}], \quad 2 \le t \le T, \quad 1 \le j \le N.$$

3) Termination:

802

$$P^* = \max_{1 \le i \le N} [\delta_T(i)]$$

$$q_t^* = \operatorname{argmax}_{1 \le i \le N} [\delta_T(i)].$$

4) Path (state sequence) backtracking:

803

$$q_t^* = \psi_{t+1}(q_t^*{}_{+1}), \quad t = T - 1, T - 2, \ldots, 1.$$

FIG. 8

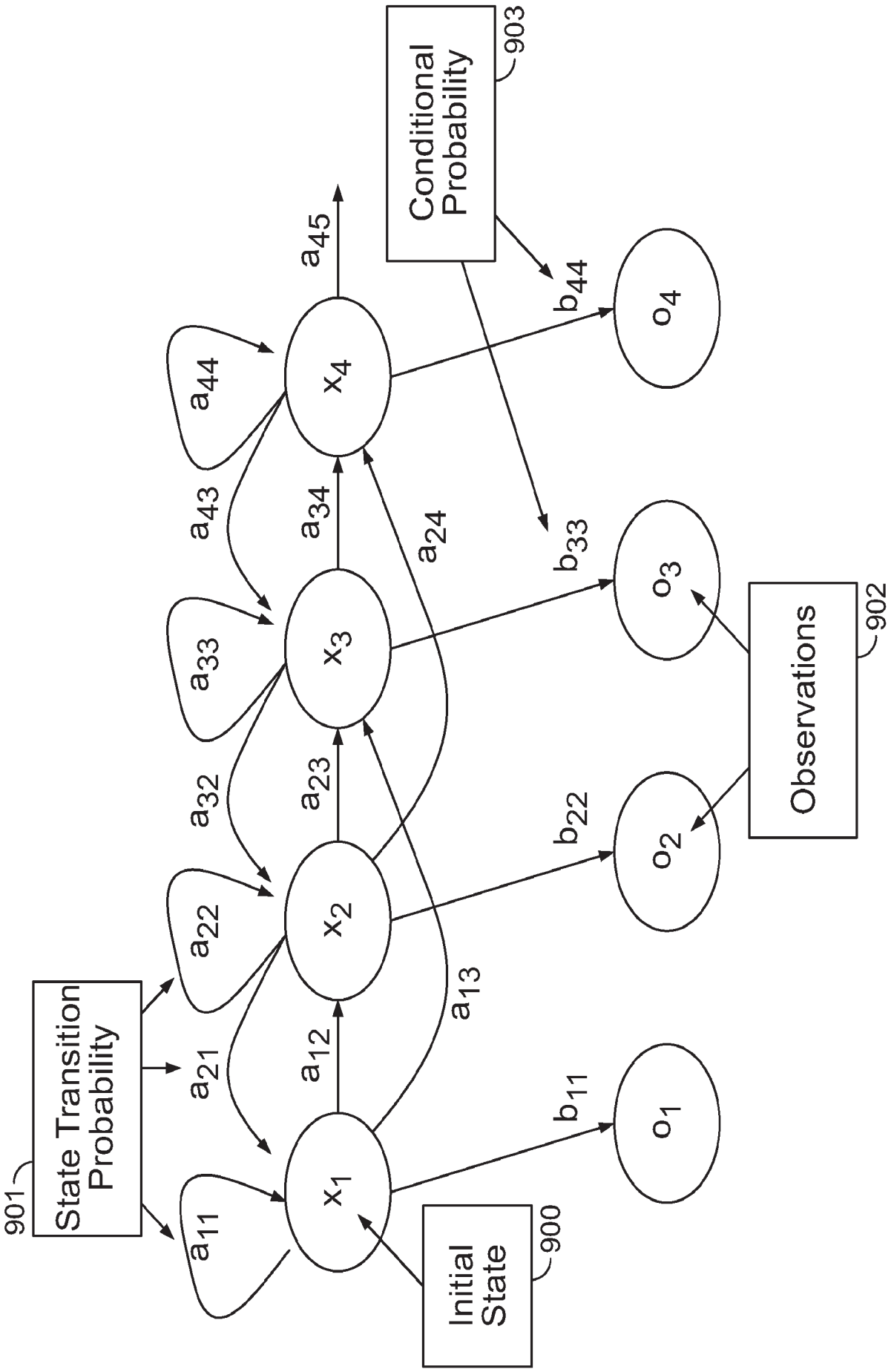

State Transition Probability
901
Initial State
900
Conditional Probability
903
Observations
902
x1
x2
x3
x4
o1
o2
o3
o4
a11
a12
a13
a21
a22
a23
a24
a32
a33
a34
a43
a44
a45
b11
b22
b33
b44

FIG. 9

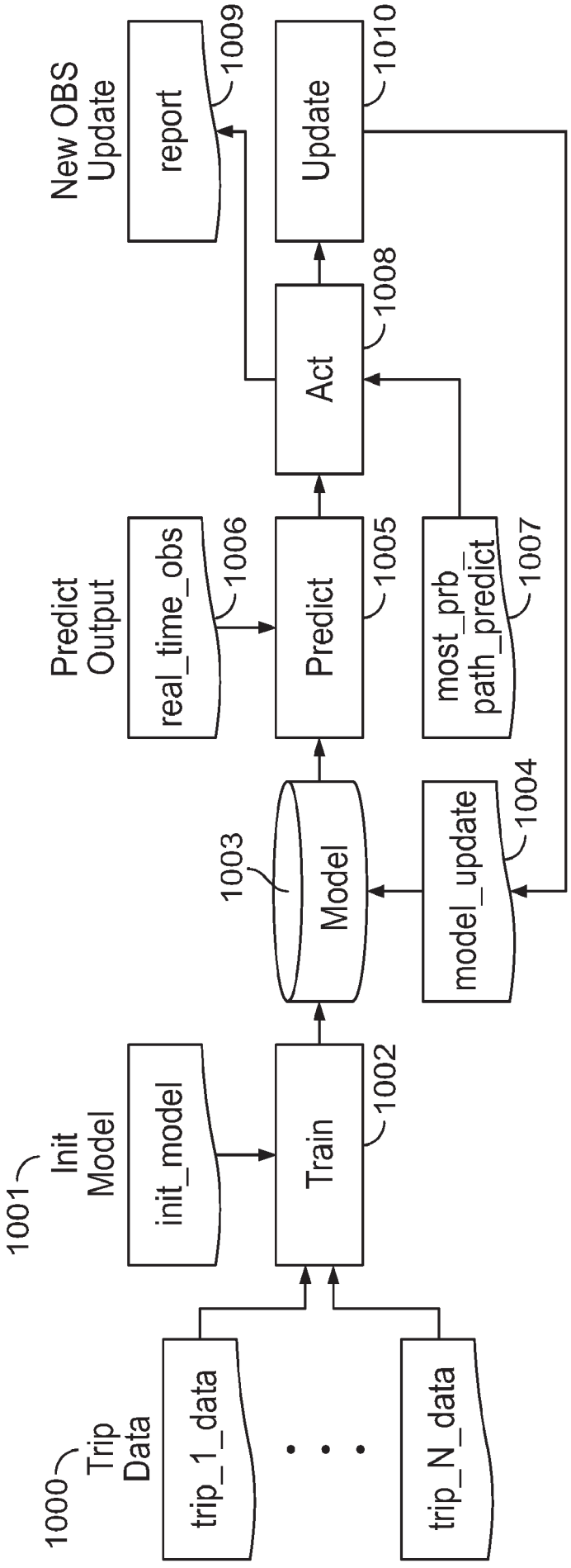

1000
Trip Data
trip_1_data
trip_N_data
1001
Init Model
init_model
Train
1002
1003
Model
model_update
1004
Predict Output
real_time_obs
1006
Predict
1005
most_prb_path_predict
1007
Act
1008
New OBS Update
report
1009
Update
1010

FIG. 10

```
Viterbi( λ, O^tT-1, T)          // α_i(t) denotes P(q_i(t)|O^tT-1)
for i=1 to |X|
  q_i(1) ← {x_i}, α_i(1) ← {1 if x_i is start state x_1, else 0}        1100
  for t=1 to T-1                //for each obs O^t ε O^tT
   for i=1 to |X|               //for each state x_t^t+1 at time t+1
     j_max ← 0, P_max ← -1                                              1101
     for k=1 to |X|             //compute arg max over x_k^t
       if (α_k(t) · P_i^t+1, O^t|x_k^t) > P_max ) then
         P_max ← α_k(t) · P(x_i^t+1, O^t|x_k^t), j_max ← k              1102
       Endif
     α_i(t+1) ← P_max                                                   1103
     q_i(t+1) ← q_jmax (t)o x_i   //postpend the next state
     Next
    Next
  Next
Next
Return q_i(T) for 0<i=|X| that maximizes α_i(T)                         1104
End
```

FIG. 11

```
Forward-Backward(obsv, prior)
/ / obsv is a vector of observational values and
/ / prior is the initial distribution of the first state          1200

/*********************************************************************
Local vars:
1. fv is a vector of forward probabilities for steps 0,...,t
2. b is a vector representation of backward probabilities, initially all 1's   1201
3. sv is a vector of smoothed estimates for steps 1,...,t

*********************************************************************/
fv[0]prior

for i=1 to t do
  / /FORWARD algorithm filters data                                1202
  fv[i] FORWARD( fv[i-1] , obsv[i])
Next

for i=t downto 1 do
  / / NORM multiplies by a constant that ensures sum is 1.
  sv[i] NORM( fv[i] x b)
  / /BACKWARD algorithm smoothes data                              1203
  b BACKWARD( b, obsv[i] )
Next
Return sv
```

FIG. 12

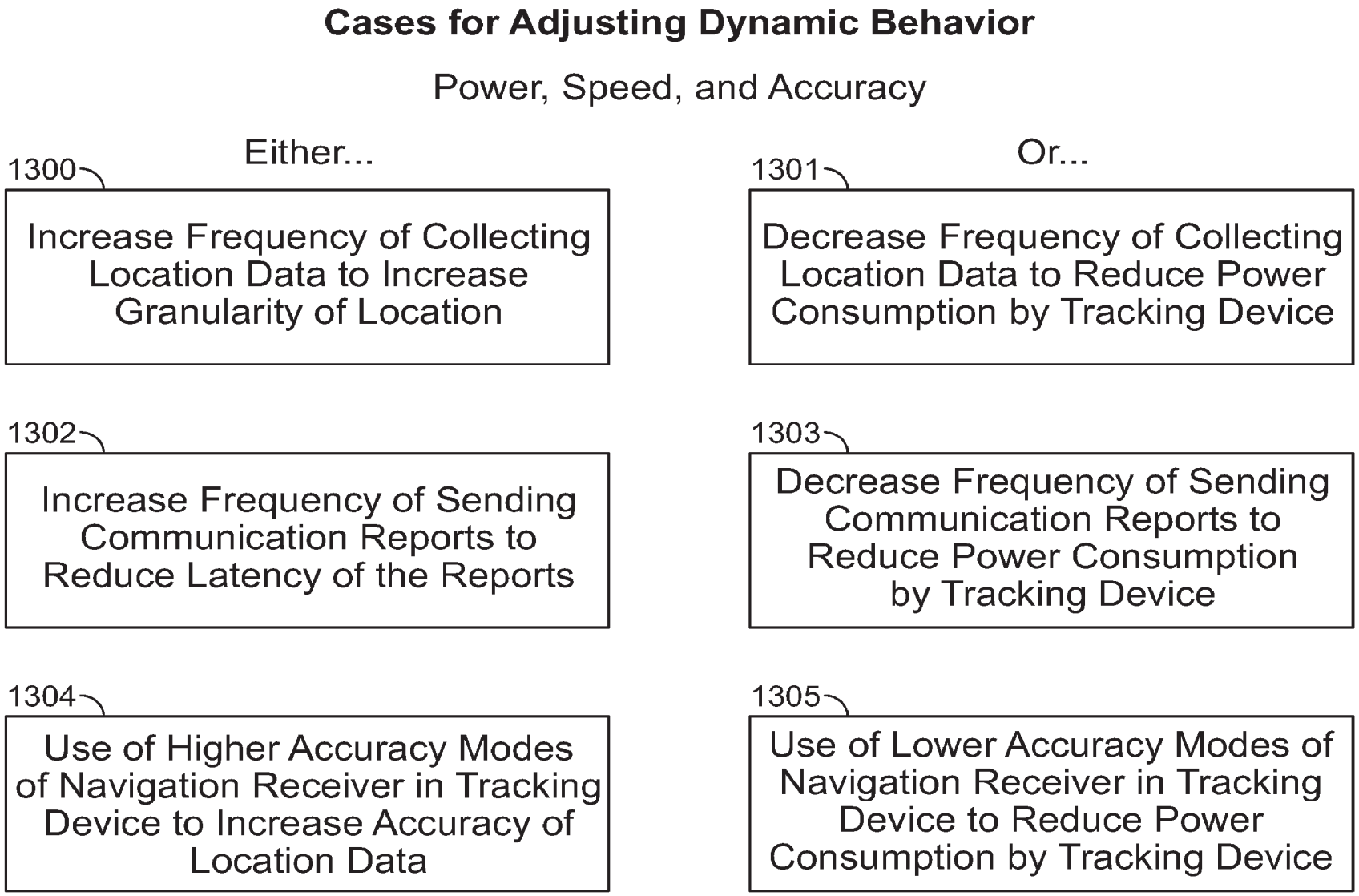

Cases for Adjusting Dynamic Behavior
Power, Speed, and Accuracy
Either...
Or...
1300
Increase Frequency of Collecting Location Data to Increase Granularity of Location
1301
Decrease Frequency of Collecting Location Data to Reduce Power Consumption by Tracking Device
1302
Increase Frequency of Sending Communication Reports to Reduce Latency of the Reports
1303
Decrease Frequency of Sending Communication Reports to Reduce Power Consumption by Tracking Device
1304
Use of Higher Accuracy Modes of Navigation Receiver in Tracking Device to Increase Accuracy of Location Data
1305
Use of Lower Accuracy Modes of Navigation Receiver in Tracking Device to Reduce Power Consumption by Tracking Device

FIG. 13A

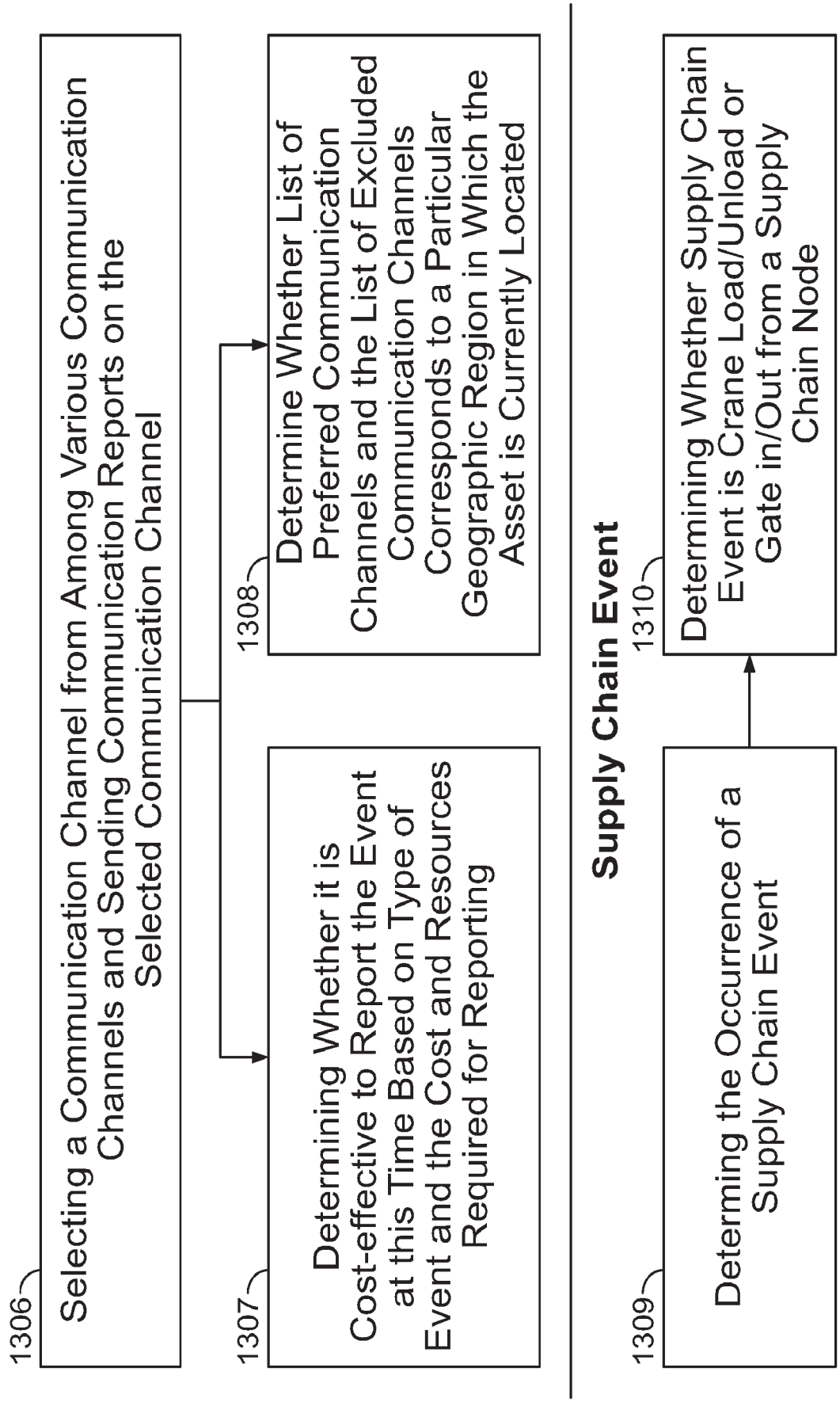

Communication Channel
1306
Selecting a Communication Channel from Among Various Communication Channels and Sending Communication Reports on the Selected Communication Channel
1307
Determining Whether it is Cost-effective to Report the Event at this Time Based on Type of Event and the Cost and Resources Required for Reporting
1308
Determine Whether List of Preferred Communication Channels and the List of Excluded Communication Channels Corresponds to a Particular Geographic Region in Which the Asset is Currently Located
Supply Chain Event
1309
Determing the Occurrence of a Supply Chain Event
1310
Determining Whether Supply Chain Event is Crane Load/Unload or Gate in/Out from a Supply Chain Node

FIG. 13B

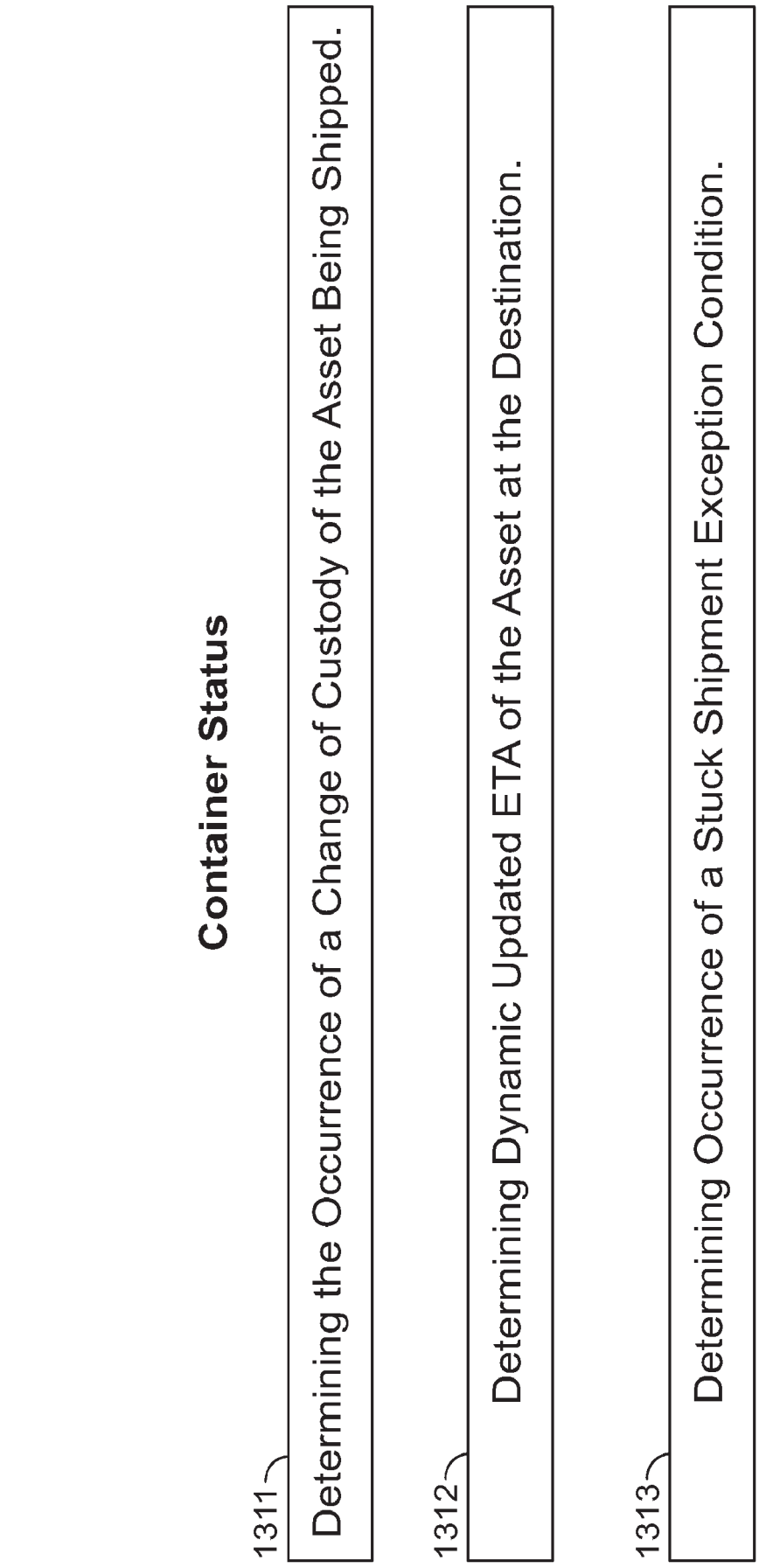

Container Status
1311
Determining the Occurrence of a Change of Custody of the Asset Being Shipped.
1312
Determining Dynamic Updated ETA of the Asset at the Destination.
1313
Determining Occurrence of a Stuck Shipment Exception Condition.

FIG. 13C

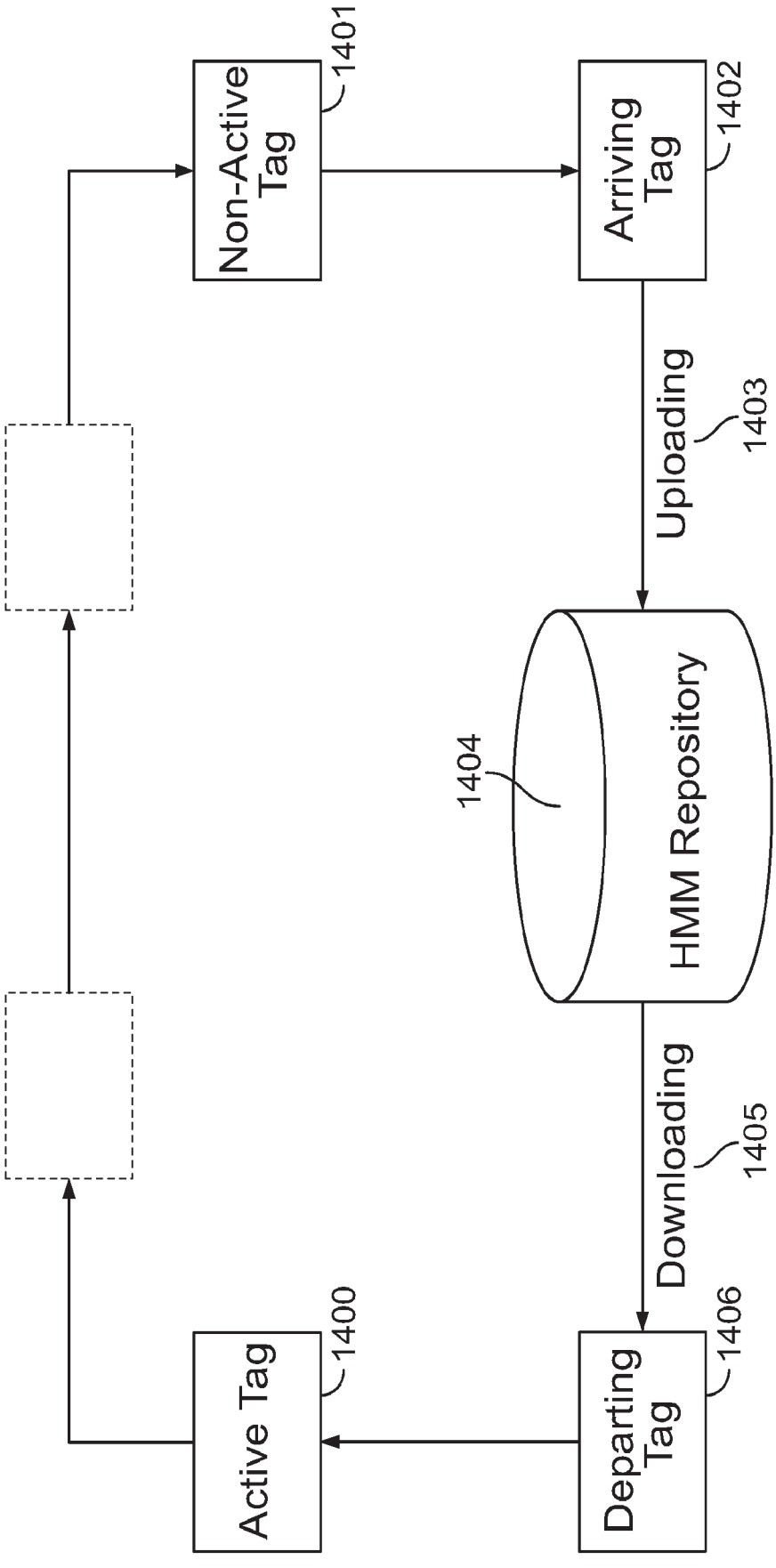

Non-Active Tag
1401
Arriving Tag
1402
Uploading
1403
HMM Repository
1404
Downloading
1405
Departing Tag
1406
Active Tag
1400

FIG. 14

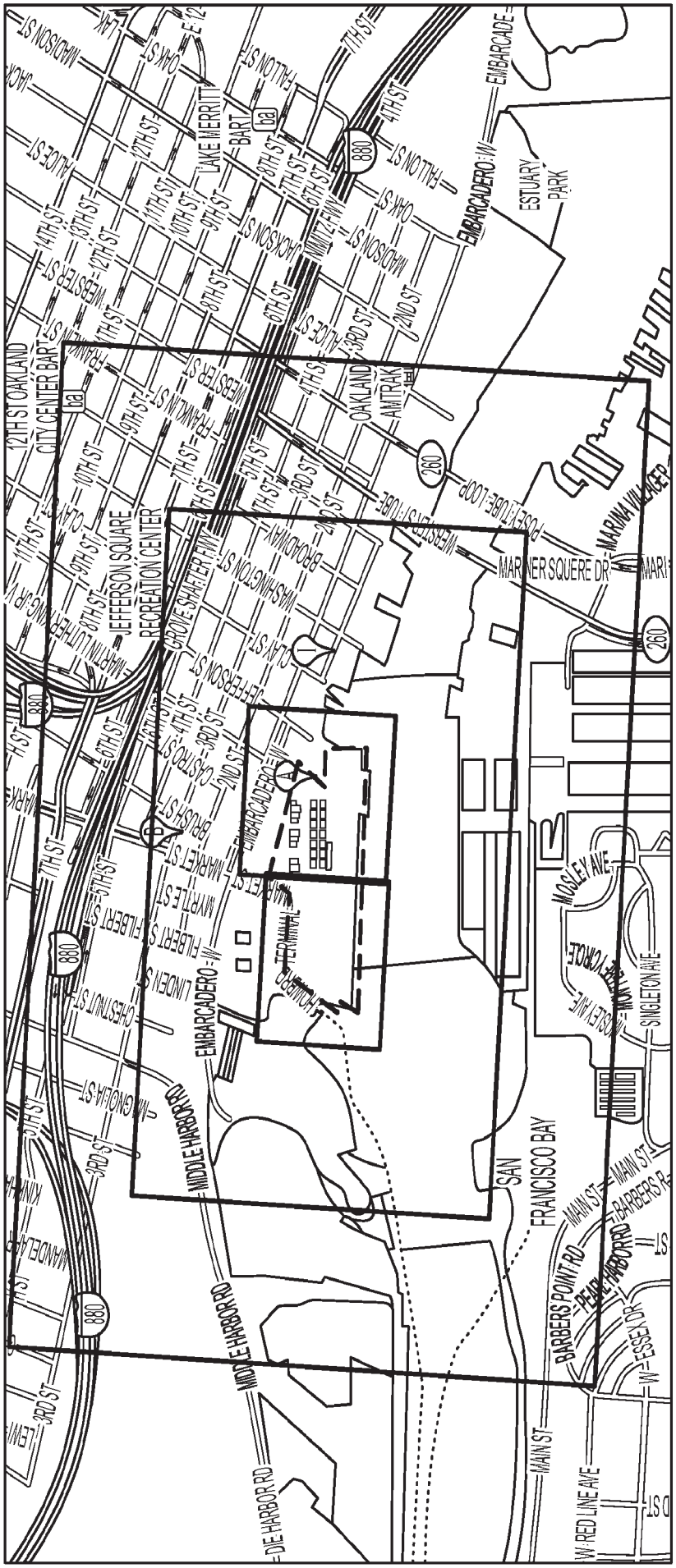

Nested Geofences with Inner Geofence of Port
12TH ST OAKLAND CITY CENTER BART
JEFFERSON SQUARE RECREATION CENTER
LAKE MERRITT BART
OAKLAND AMTRAK
ESTUARY PARK
MARINA VILLAGE
MARINER SQUERE DR
EMBARCADERO W
MIDDLE HARBOR RD
SAN FRANCISCO BAY
BARBERS POINT RD
MAIN ST
W RED LINE AVE
880
260
980

FIG. 15

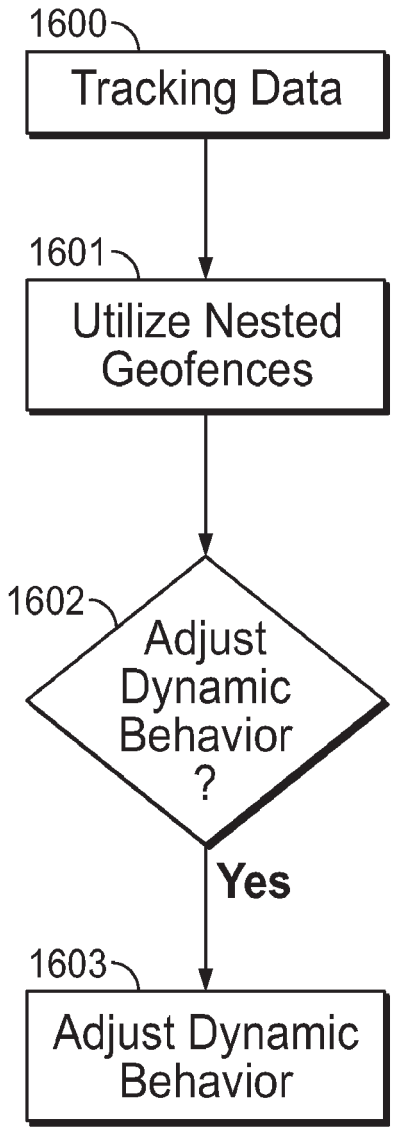

1600
Tracking Data
1601
Utilize Nested Geofences
1602
Adjust Dynamic Behavior ?
Yes
1603
Adjust Dynamic Behavior

FIG. 16

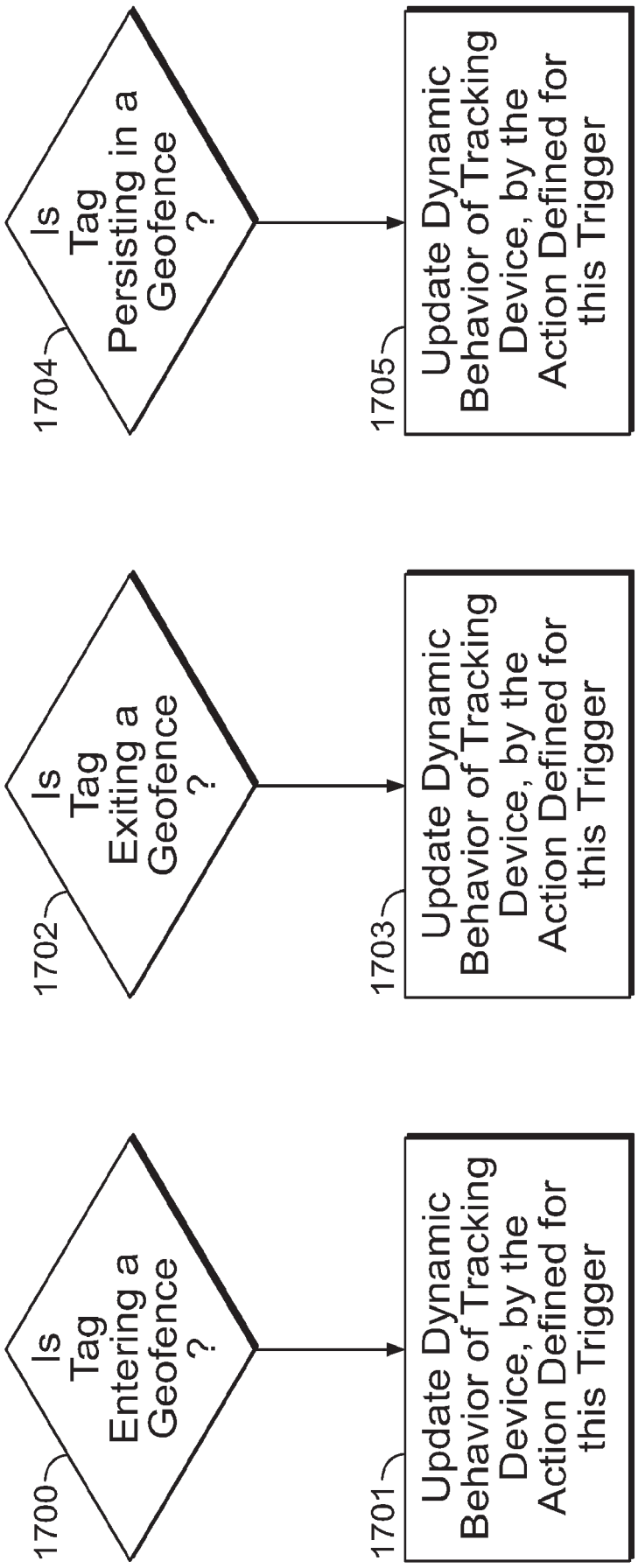

Is Tag Entering a Geofence ?
1700
Update Dynamic Behavior of Tracking Device, by the Action Defined for this Trigger
1701
Is Tag Exiting a Geofence ?
1702
Update Dynamic Behavior of Tracking Device, by the Action Defined for this Trigger
1703
Is Tag Persisting in a Geofence ?
1704
Update Dynamic Behavior of Tracking Device, by the Action Defined for this Trigger
1705

FIG. 17

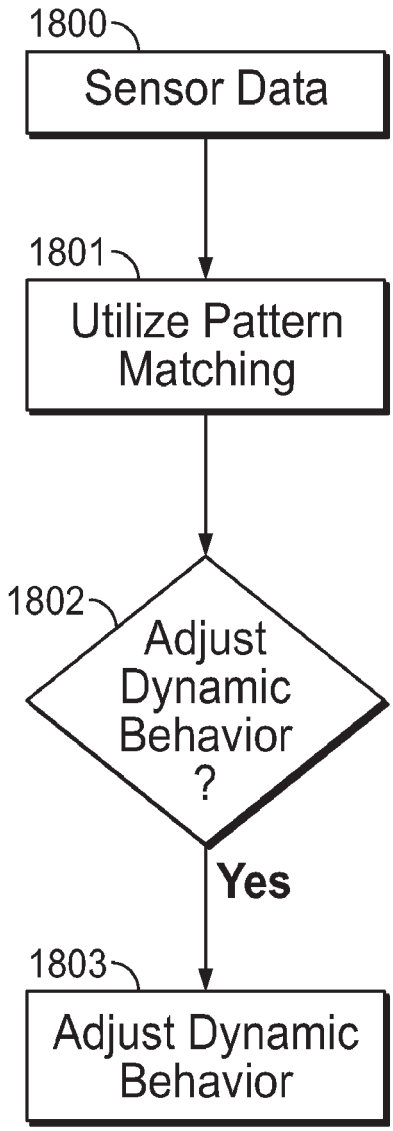

1800
Sensor Data
1801
Utilize Pattern Matching
1802
Adjust Dynamic Behavior ?
Yes
1803
Adjust Dynamic Behavior

FIG. 18

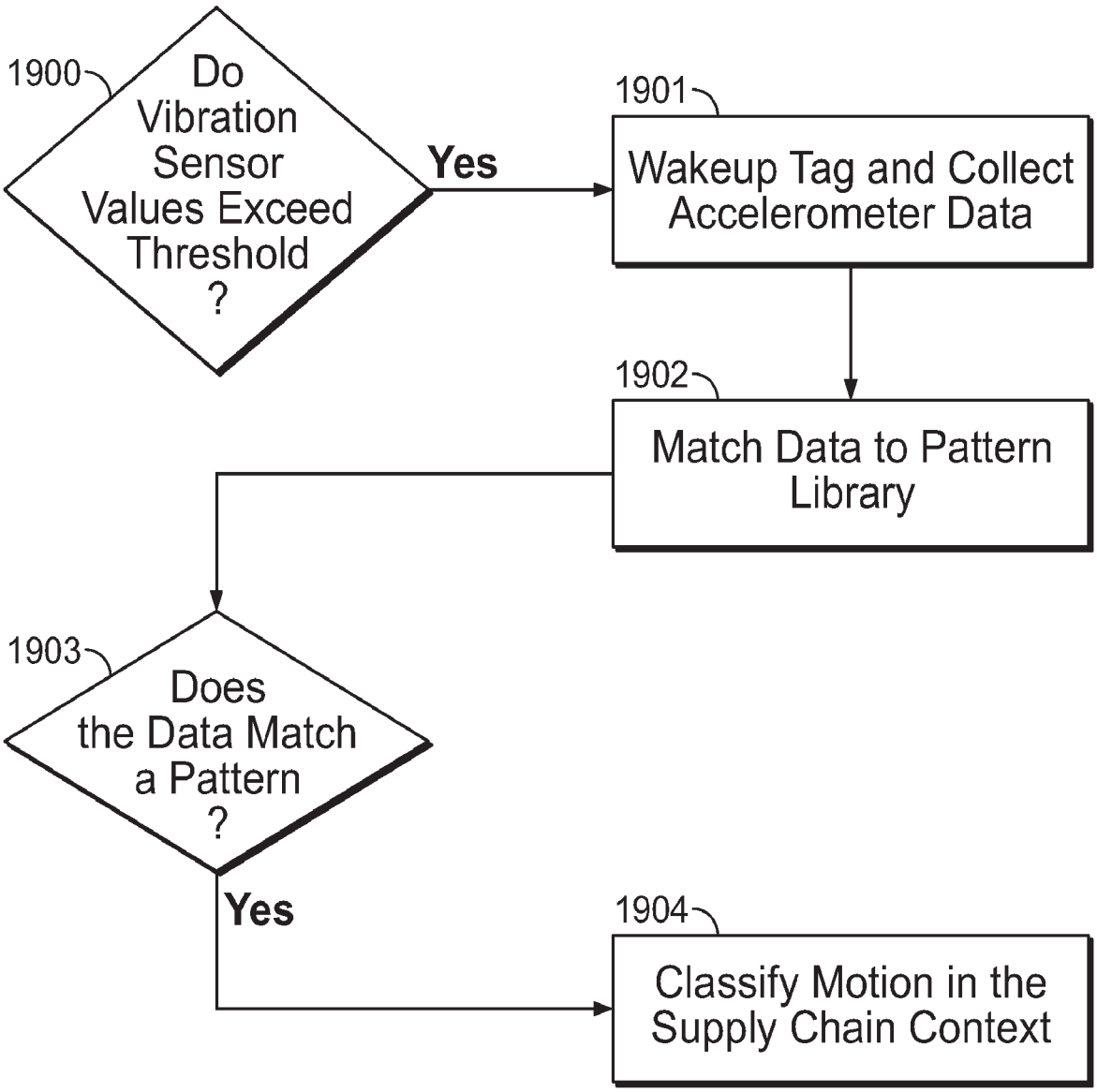

1900
Do Vibration Sensor Values Exceed Threshold ?
Yes
1901
Wakeup Tag and Collect Accelerometer Data
1902
Match Data to Pattern Library
1903
Does the Data Match a Pattern ?
Yes
1904
Classify Motion in the Supply Chain Context

FIG. 19

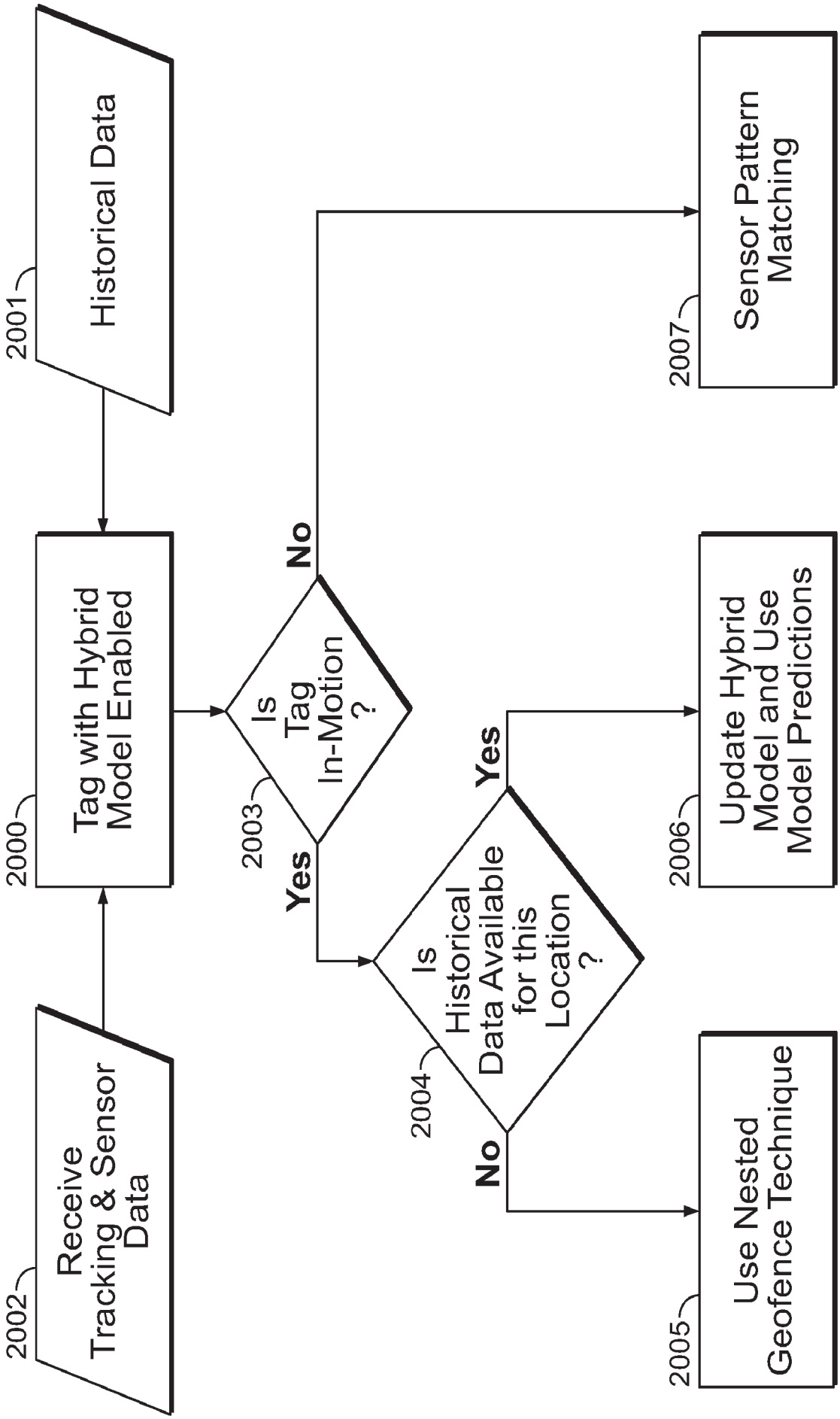

2001
Historical Data
2000
Tag with Hybrid Model Enabled
2002
Receive Tracking & Sensor Data
2003
Is Tag In-Motion ?
No
Yes
2004
Is Historical Data Available for this Location ?
Yes
No
2006
Update Hybrid Model and Use Model Predictions
2005
Use Nested Geofence Technique
2007
Sensor Pattern Matching

FIG. 20

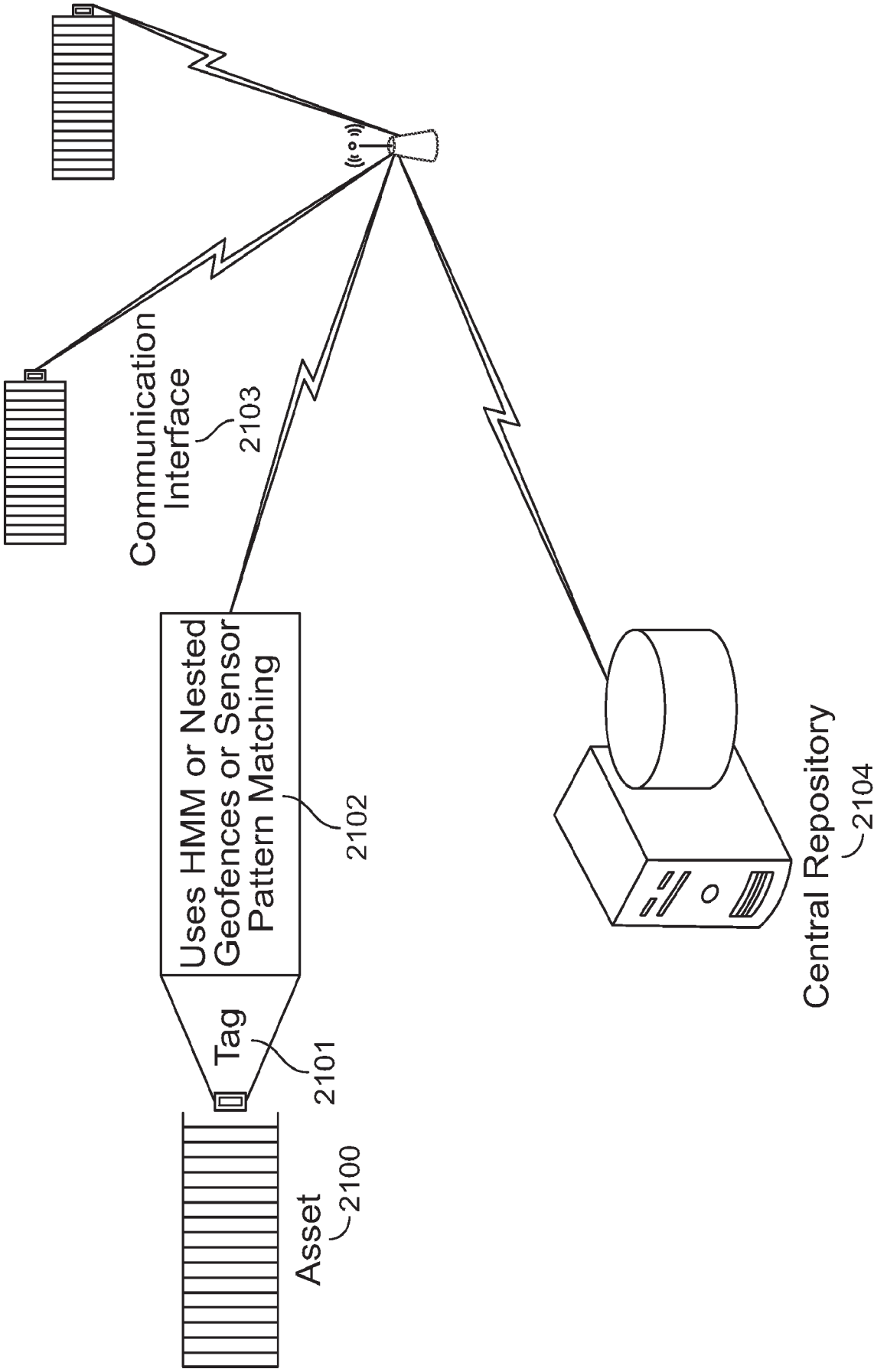

Communication Interface
2103
Uses HMM or Nested Geofences or Sensor Pattern Matching
2102
Tag
2101
Asset
2100
Central Repository
2104

FIG. 21