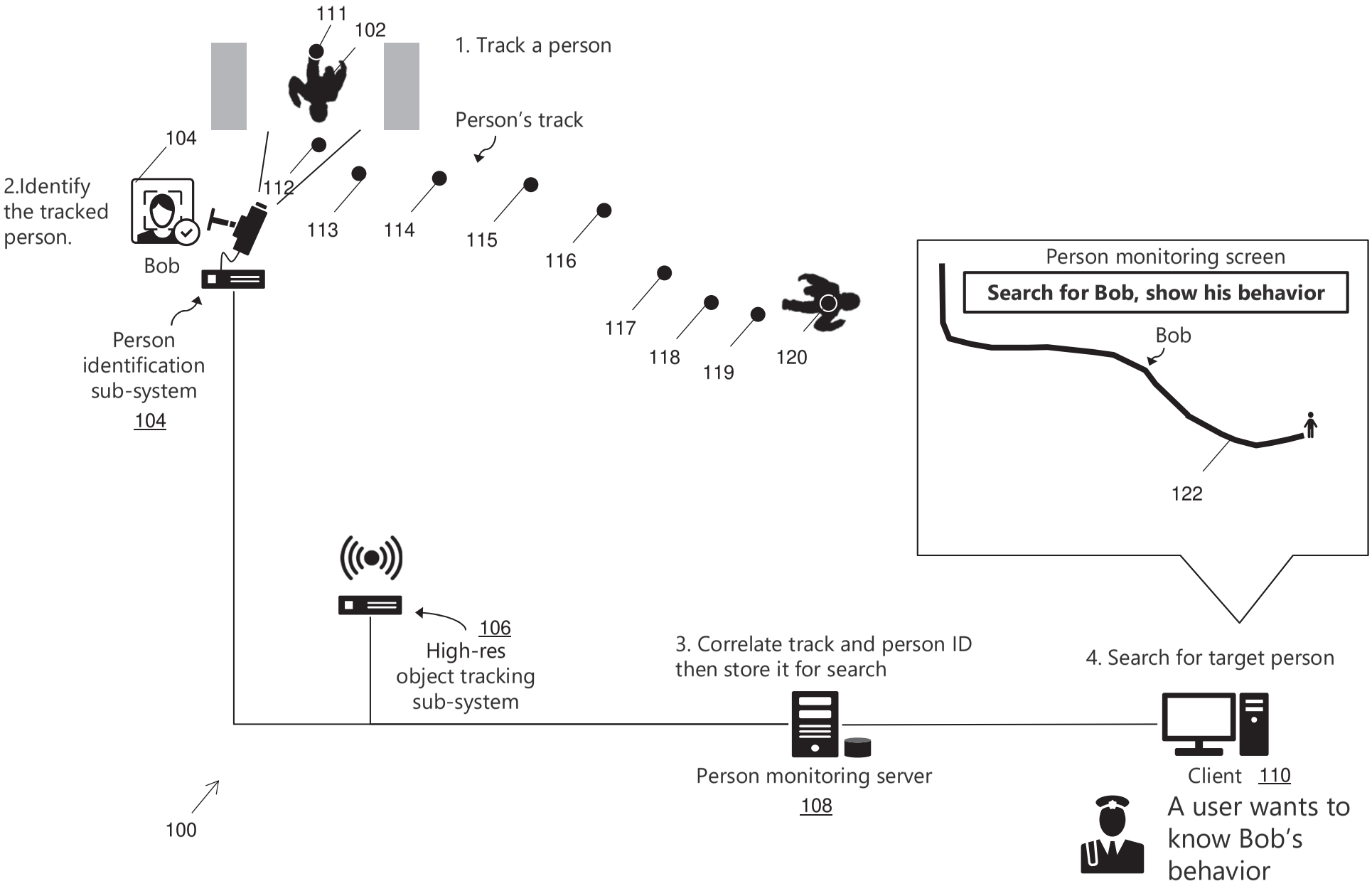

111
102
1. Track a person
Person's track
104
2.Identify the tracked person.
112
113
114
115
116
117
118
119
120
Bob
Person identification sub-system
104
Person monitoring screen
Search for Bob, show his behavior
Bob
122
106
High-res object tracking sub-system
3. Correlate track and person ID then store it for search
4. Search for target person
Person monitoring server
108
Client 110
A user wants to know Bob's behavior
100

Figure 1

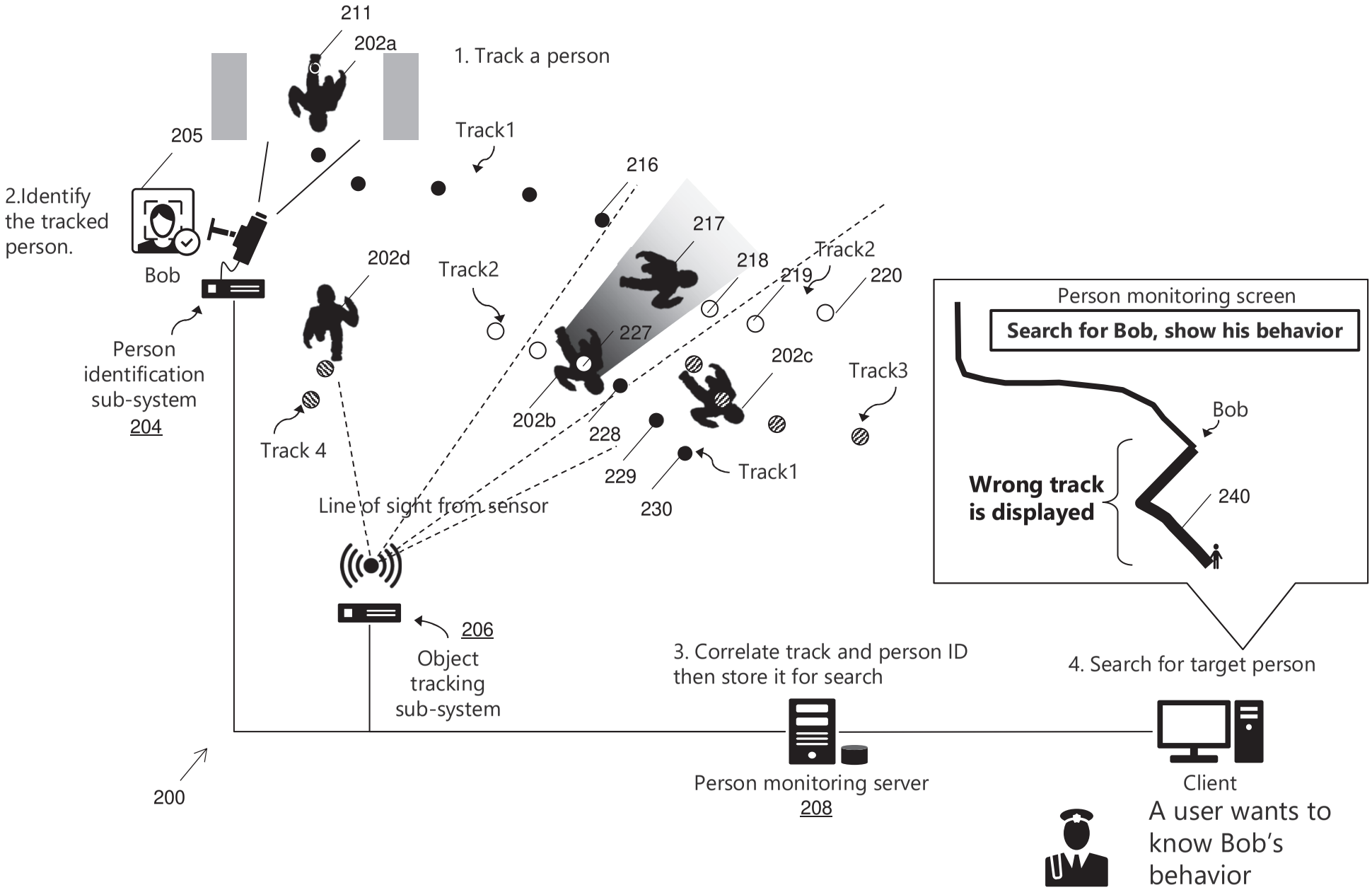

211
202a
1. Track a person
205
Track1
216
2.Identify the tracked person.
217
218
Track2
219
220
Bob
202d
Track2
227
Person identification sub-system 204
202c
Track3
202b
228
Track 4
229
Track1
230
Line of sight from sensor
206
Object tracking sub-system
3. Correlate track and person ID then store it for search
Person monitoring server 208
200
Person monitoring screen
Search for Bob, show his behavior
Bob
Wrong track is displayed
240
4. Search for target person
Client
A user wants to know Bob's behavior

Figure 2

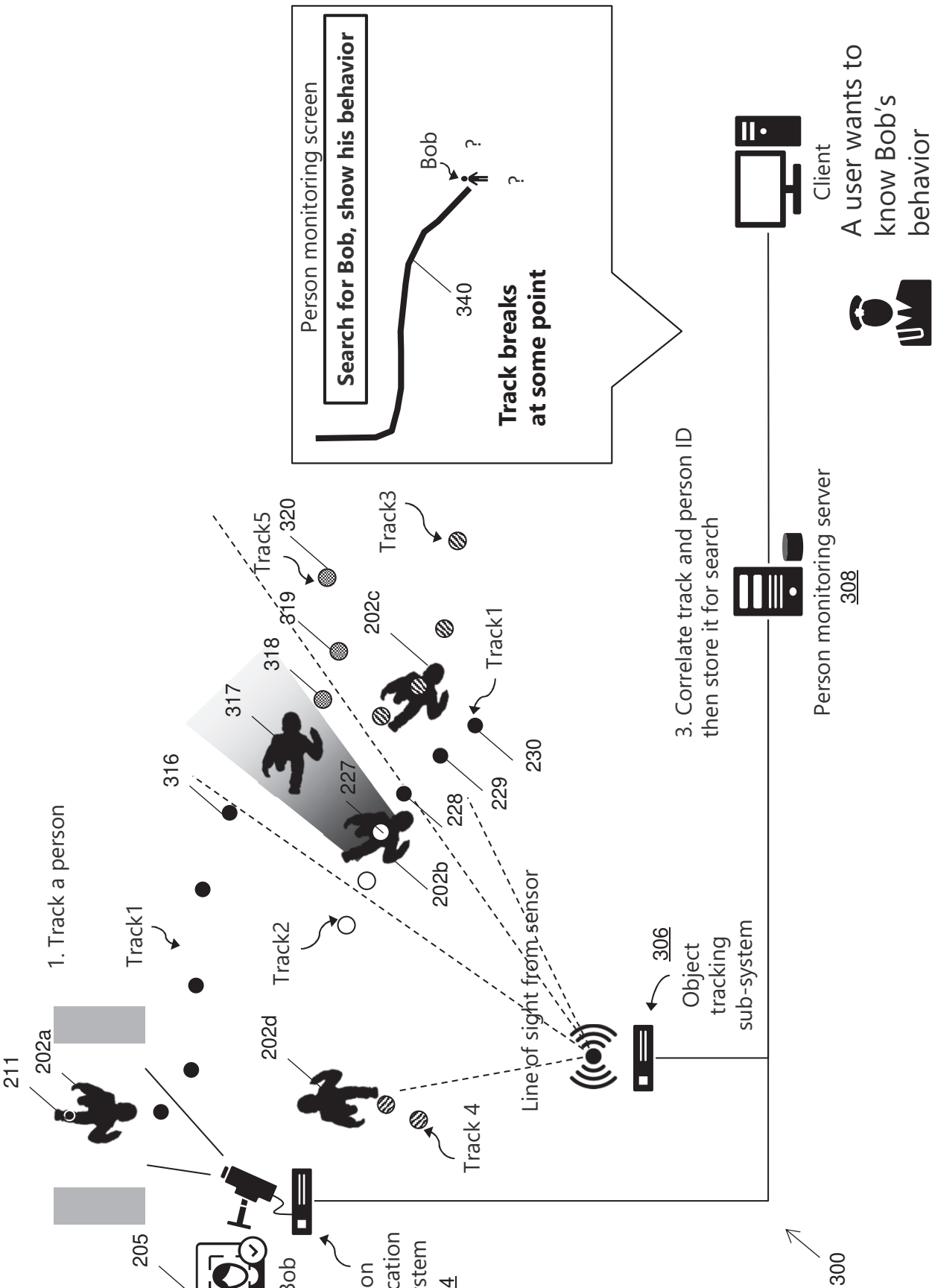

Person monitoring screen
Search for Bob, show his behavior
Bob
?
?
340
Track breaks at some point
Client
A user wants to know Bob's behavior
3. Correlate track and person ID then store it for search
Person monitoring server 308
306
Object tracking sub-system
Line of sight from sensor
1. Track a person
2.Identify the tracked person.
Person identification sub-system 204
Bob
205
211
202a
202b
202c
202d
Track1
Track2
Track3
Track4
Track5
Track1
316
317
318
319
320
227
228
229
230
300

Figure 3

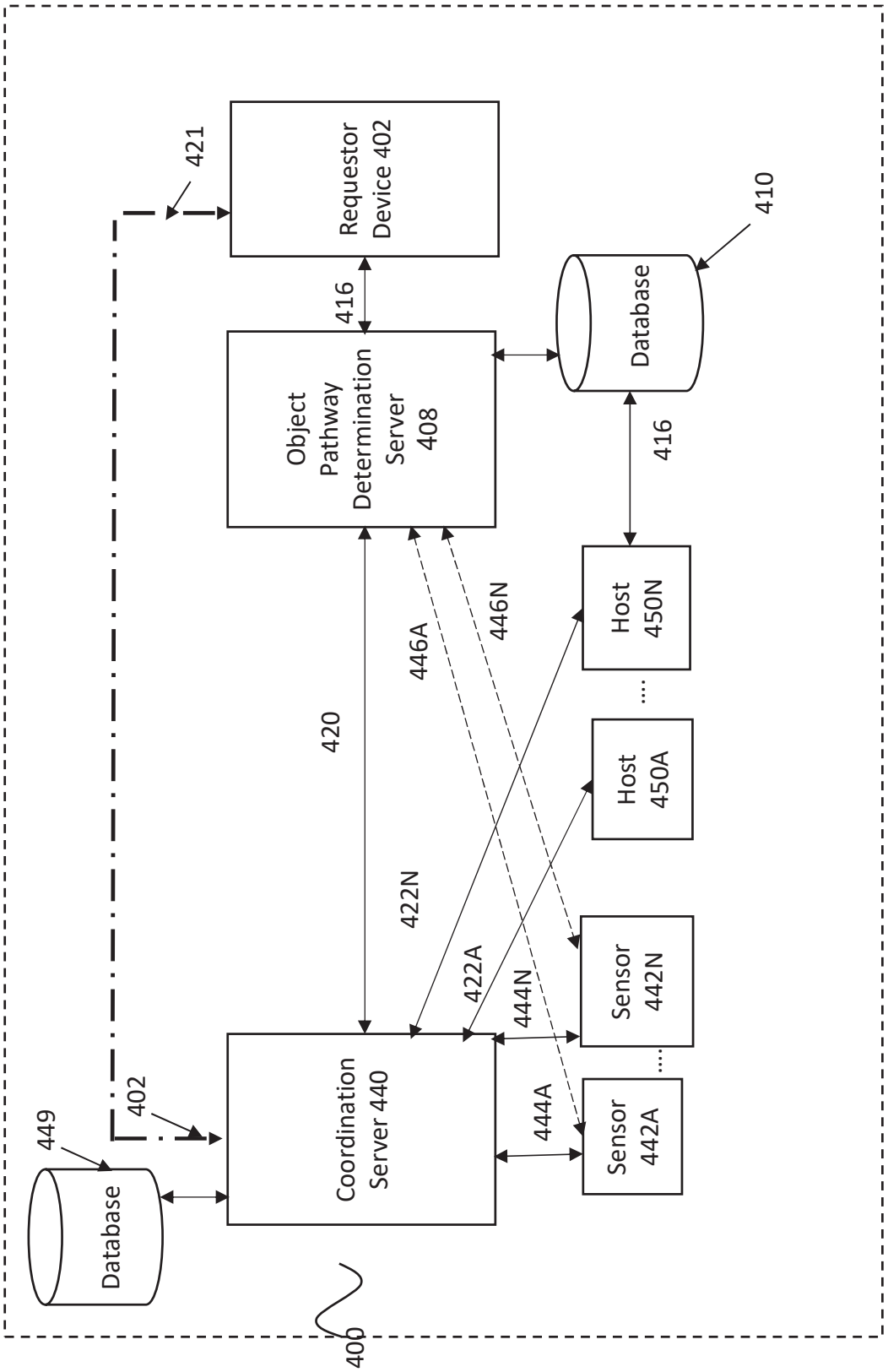

400
Database
449
402
Coordination Server 440
444A
Sensor 442A
444N
Sensor 442N
422A
422N
420
446A
446N
Host 450A
Host 450N
Object Pathway Determination Server 408
416
Database
410
416
Requestor Device 402
421

Figure 4

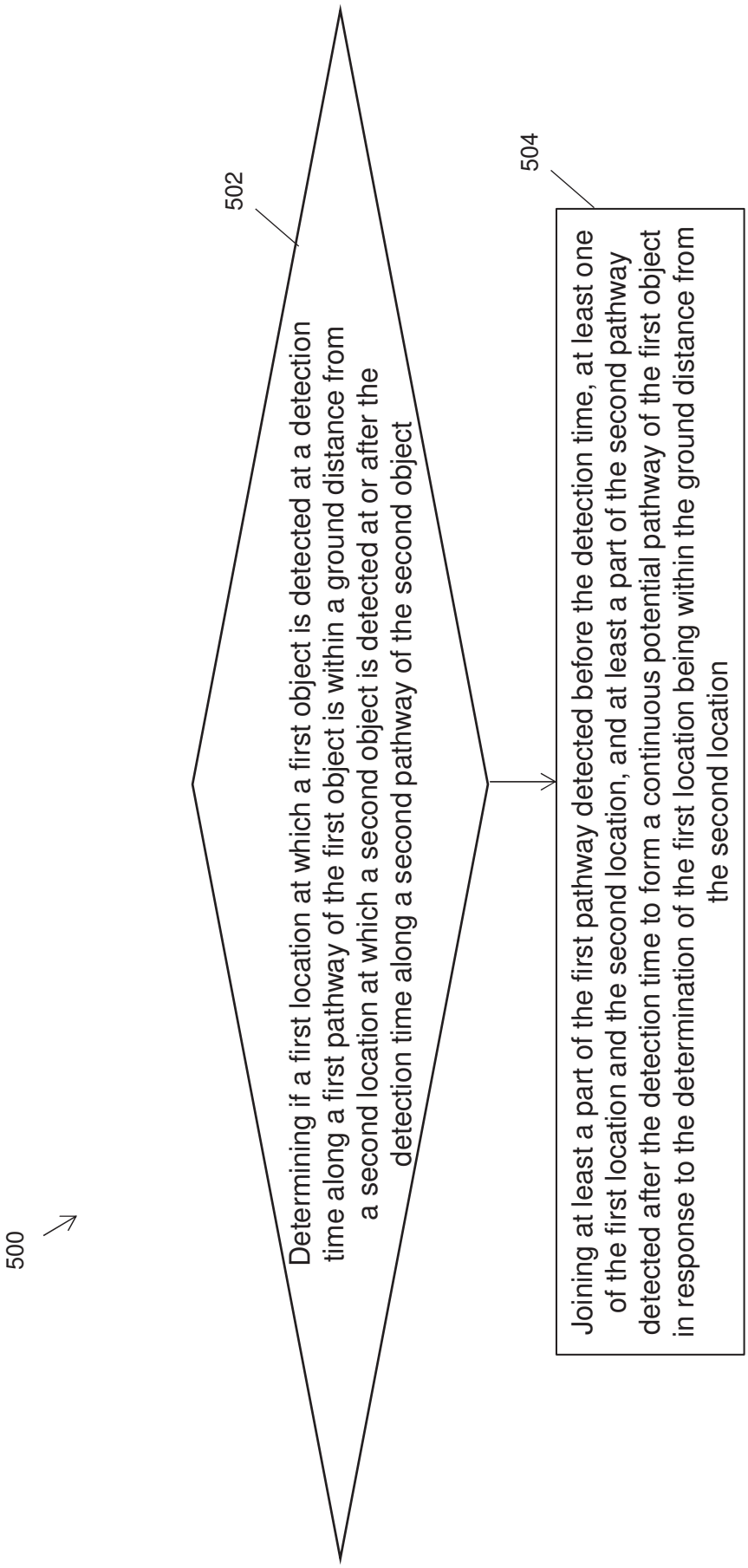

500
502
Determining if a first location at which a first object is detected at a detection time along a first pathway of the first object is within a ground distance from a second location at which a second object is detected at or after the detection time along a second pathway of the second object
504
Joining at least a part of the first pathway detected before the detection time, at least one of the first location and the second location, and at least a part of the second pathway detected after the detection time to form a continuous potential pathway of the first object in response to the determination of the first location being within the ground distance from the second location

Figure 5

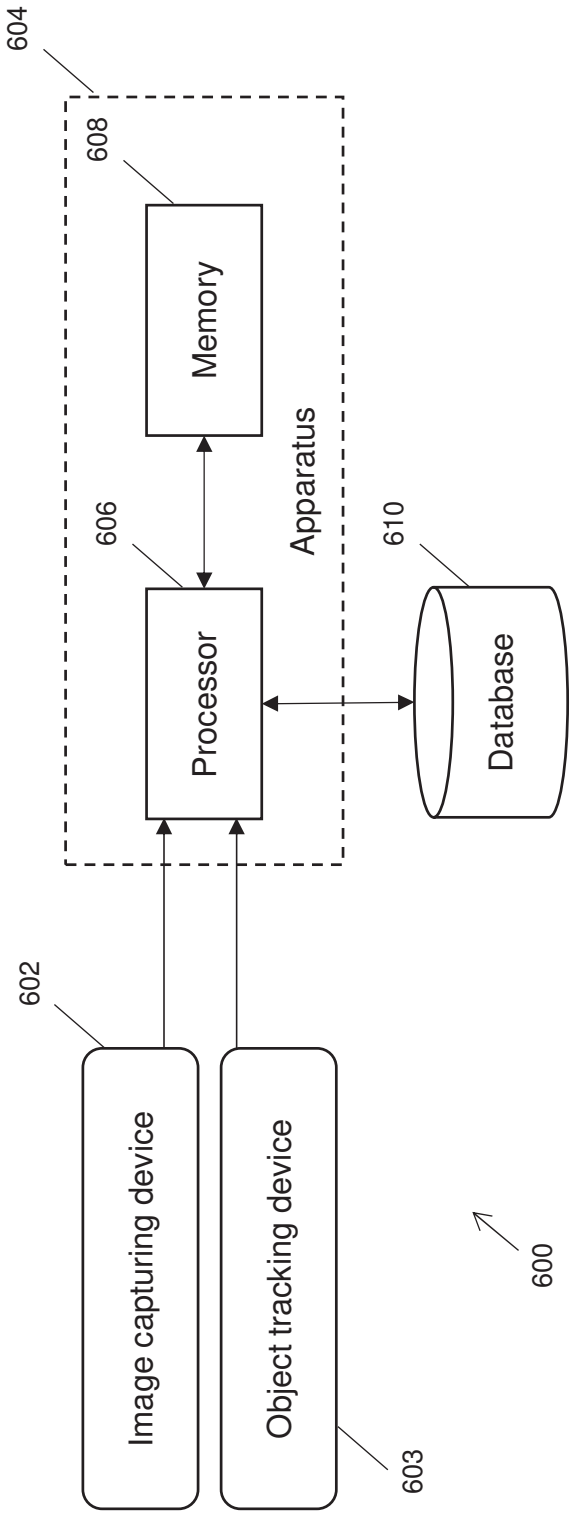

604
608
Memory
606
Processor
Apparatus
610
Database
602
Image capturing device
Object tracking device
603
600

Figure 6

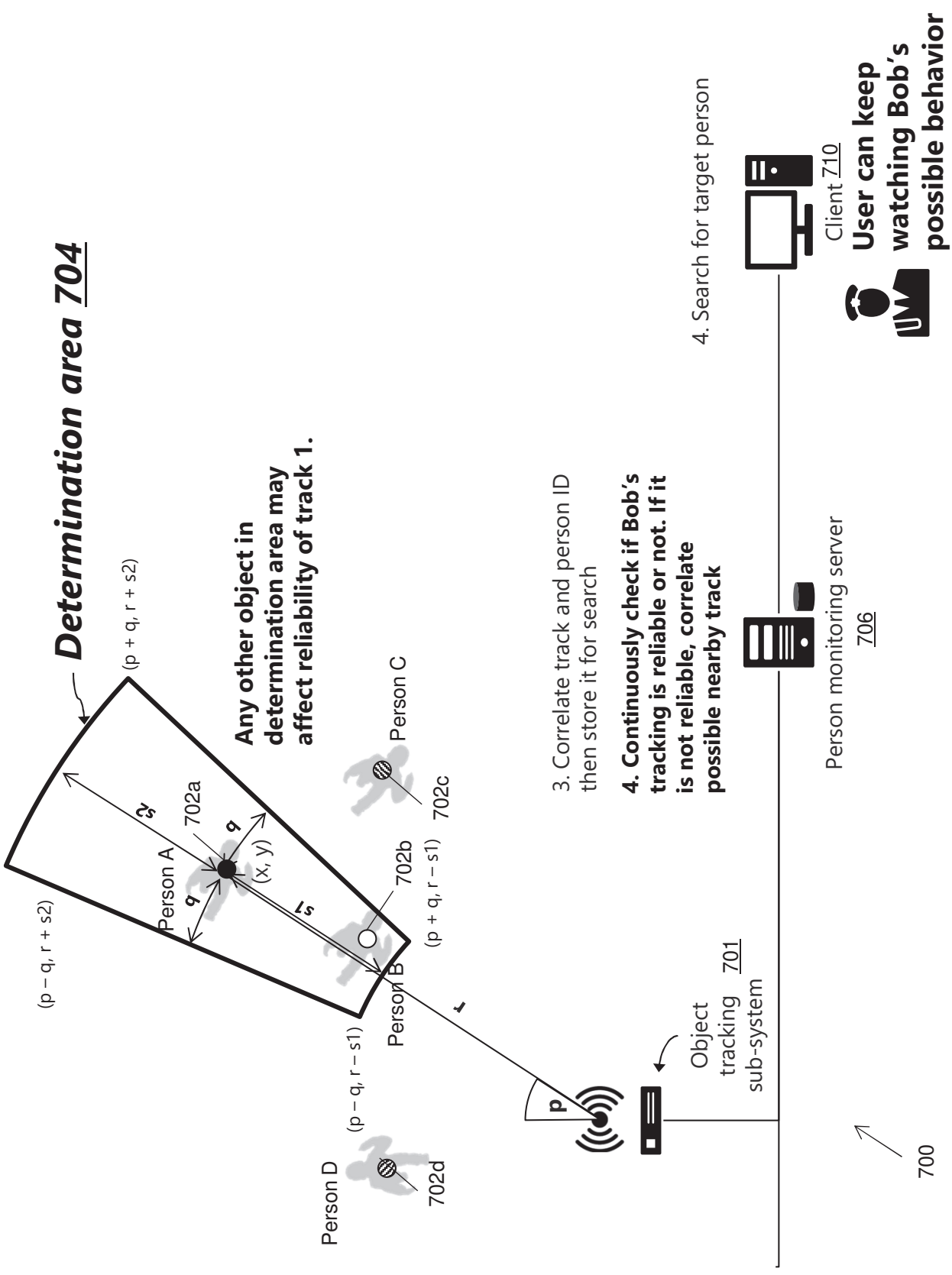

Determination area 704
(p + q, r + s2)
(p – q, r + s2)
Any other object in determination area may affect reliability of track 1.
Person A
702a
(x, y)
Person B
702b
(p + q, r – s1)
(p – q, r – s1)
Person C
702c
Person D
702d
3. Correlate track and person ID then store it for search
4. Continuously check if Bob's tracking is reliable or not. If it is not reliable, correlate possible nearby track
Object tracking sub-system 701
Person monitoring server 706
4. Search for target person
Client 710
User can keep watching Bob's possible behavior
700

Figure 7

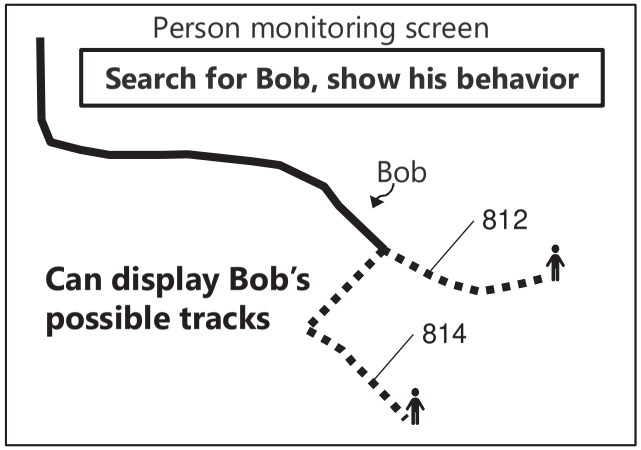


Figure 8A

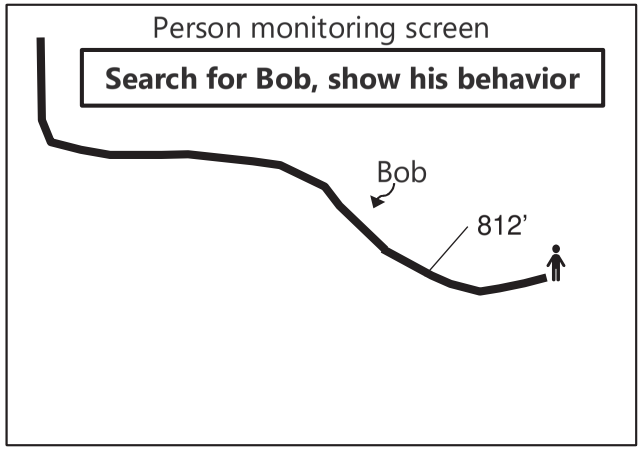


Figure 8B

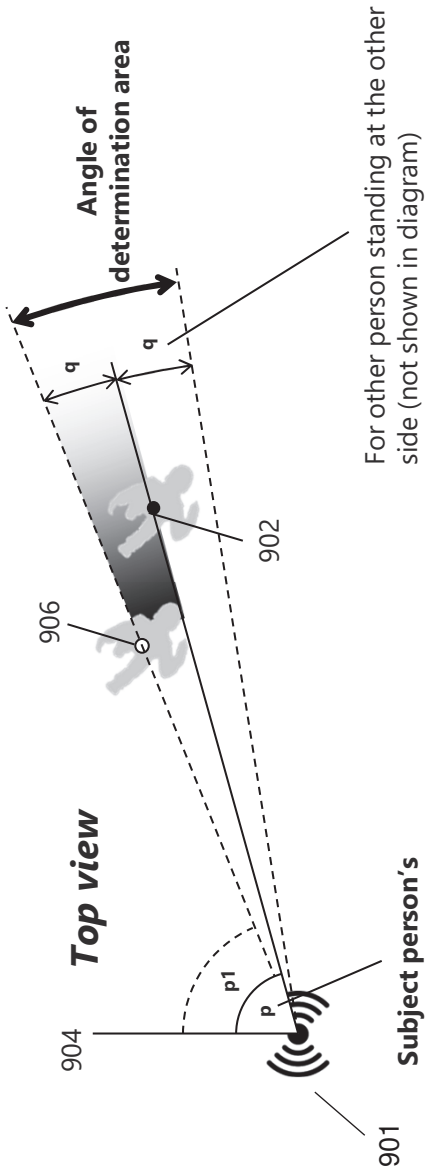

Angle of determination area
q
q
For other person standing at the other side (not shown in diagram)
902
906
Top view
p1
P
904
Subject person's angle
901
900

Figure 9

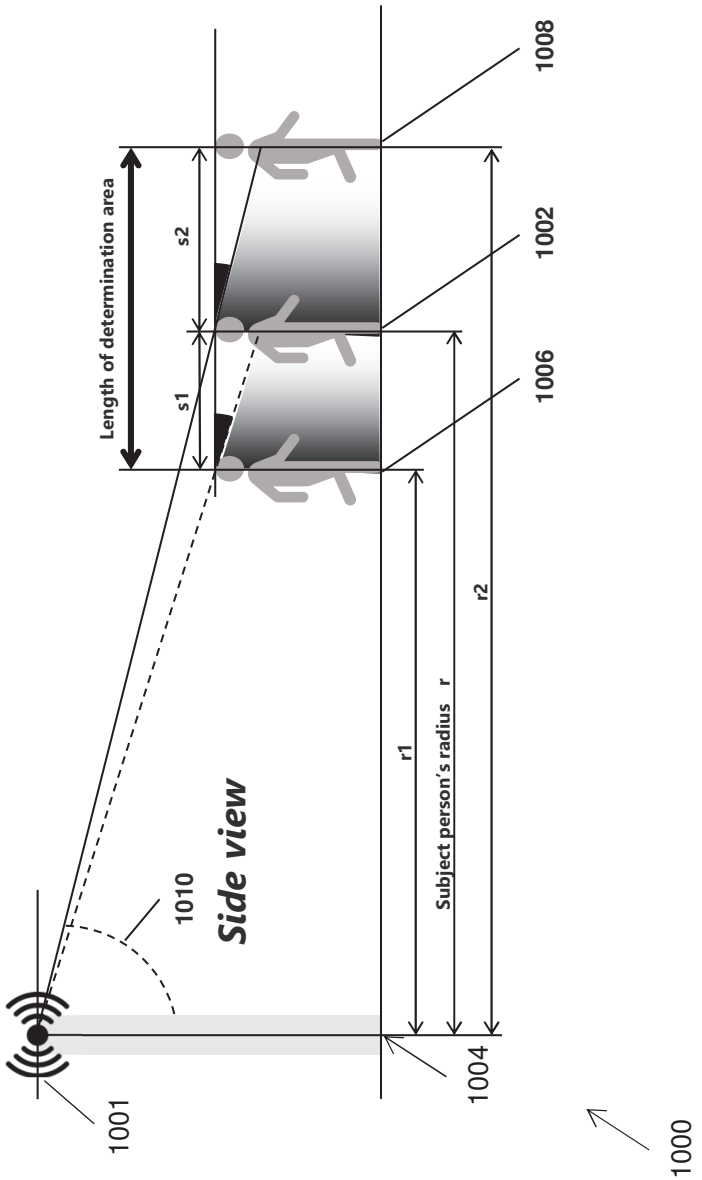

Length of determination area
s2
s1
1008
1002
1006
r2
r1
Subject person's radius r
Side view
1010
1001
1004
1000

Figure 10

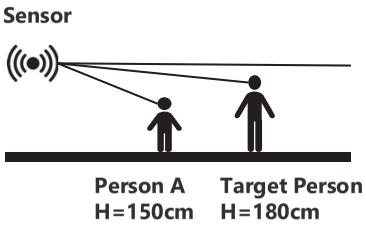


Figure 11A

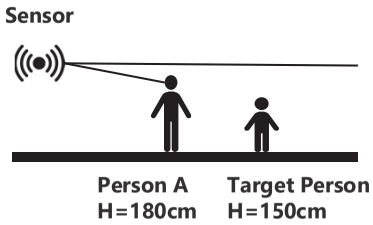


Figure 11B

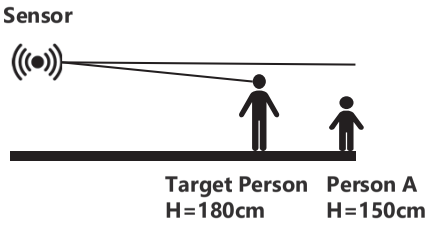


Figure 11C

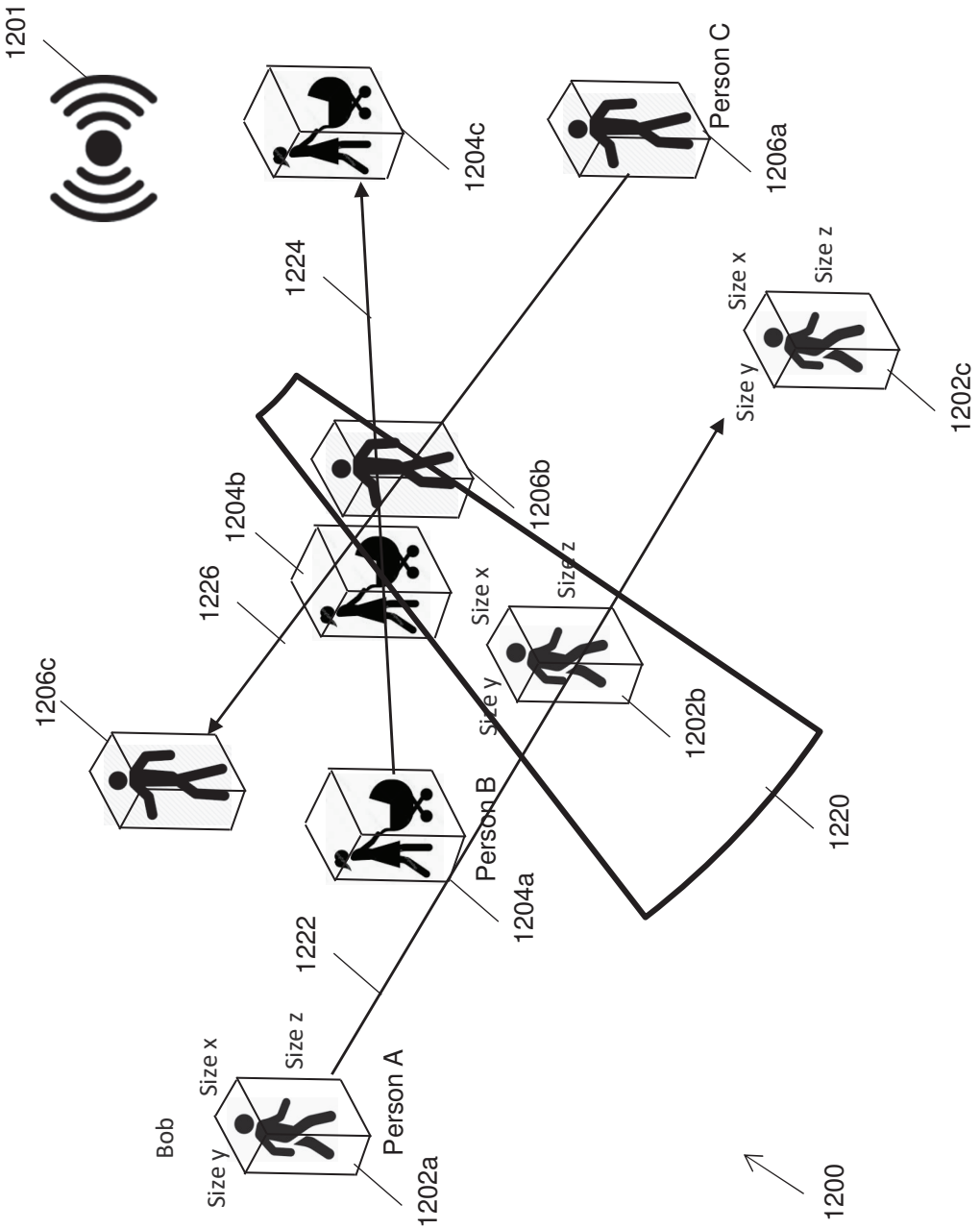

1201
1204c
1224
Person C
1206a
Size x
Size z
Size y
1202c
1204b
1206b
1226
Size x
Size z
Size y
1202b
1206c
1220
Person B
1204a
1222
Bob
Size x
Size z
Person A
Size y
1202a
1200

Figure 12

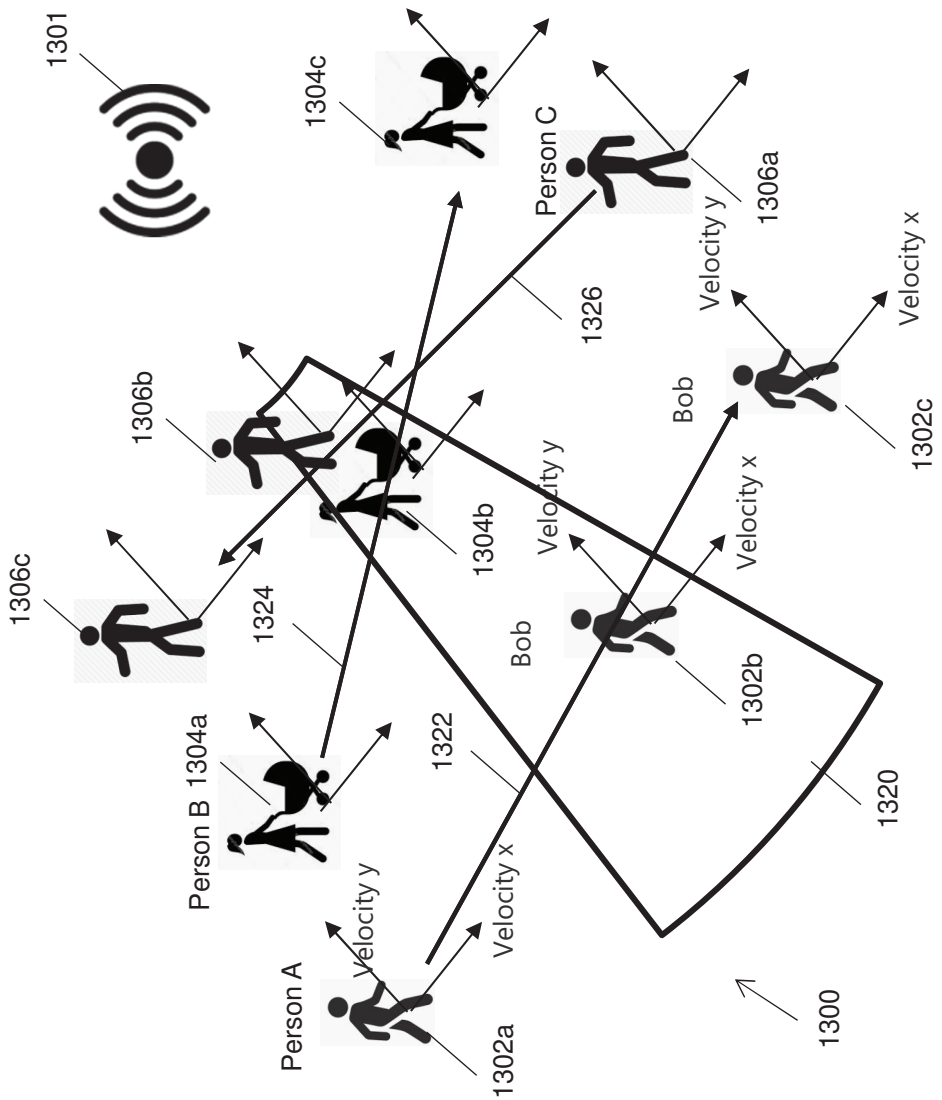

1301
1304c
Person C
1306a
Velocity y
Velocity x
1326
1306b
Bob
1304b
Velocity y
Velocity x
1306c
1324
Person B
1304a
1322
Bob
1302b
1302c
1320
Velocity y
Velocity x
Person A
1302a
1300

Figure 13

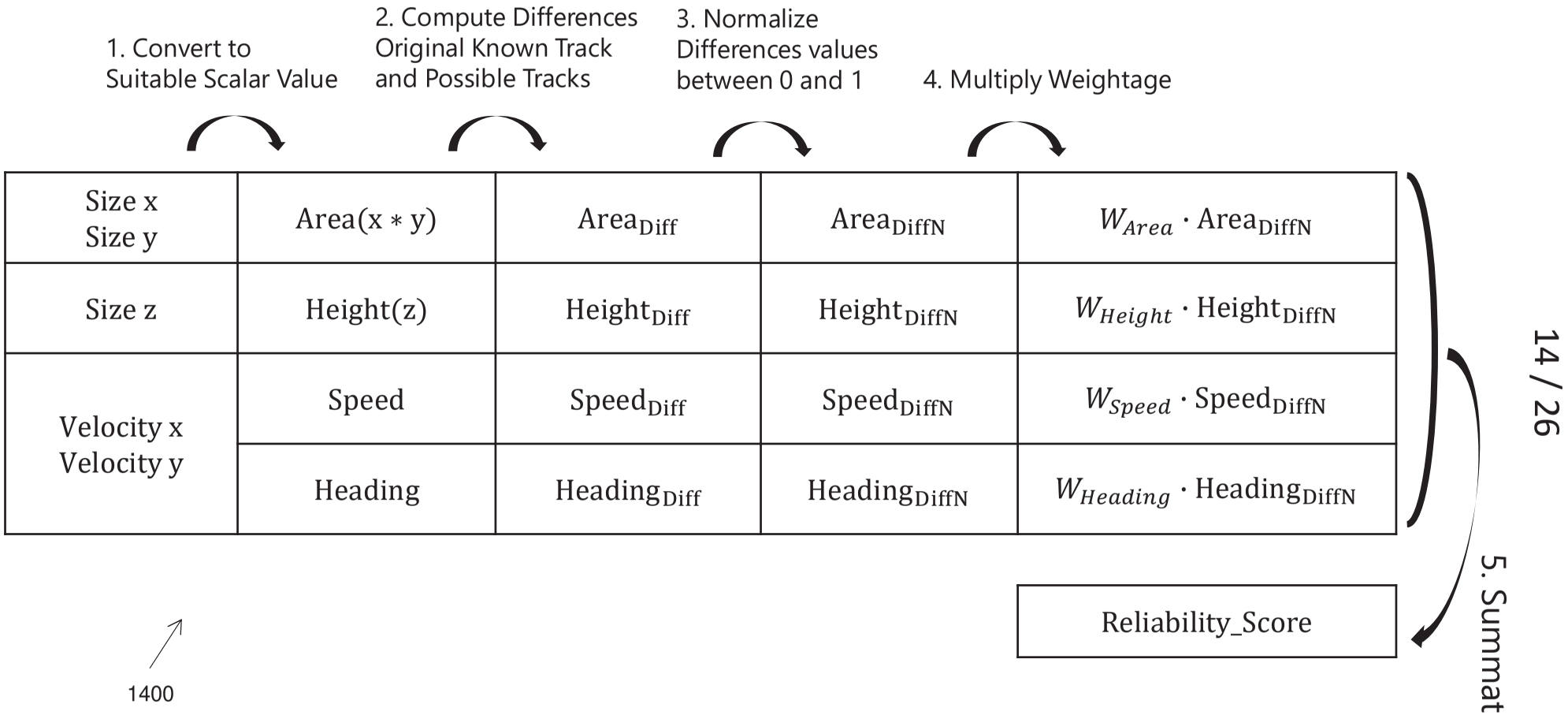

1. Convert to Suitable Scalar Value
2. Compute Differences Original Known Track and Possible Tracks
3. Normalize Differences values between 0 and 1
4. Multiply Weightage
Size x
Size y
Area(x ∗ y)
$\text{Area}_{\text{Diff}}$
$\text{Area}_{\text{DiffN}}$
$W_{Area} \cdot \text{Area}_{\text{DiffN}}$
Size z
Height(z)
$\text{Height}_{\text{Diff}}$
$\text{Height}_{\text{DiffN}}$
$W_{Height} \cdot \text{Height}_{\text{DiffN}}$
Velocity x
Velocity y
Speed
$\text{Speed}_{\text{Diff}}$
$\text{Speed}_{\text{DiffN}}$
$W_{Speed} \cdot \text{Speed}_{\text{DiffN}}$
Heading
$\text{Heading}_{\text{Diff}}$
$\text{Heading}_{\text{DiffN}}$
$W_{Heading} \cdot \text{Heading}_{\text{DiffN}}$
Reliability_Score
5. Summation
1400

Figure 14

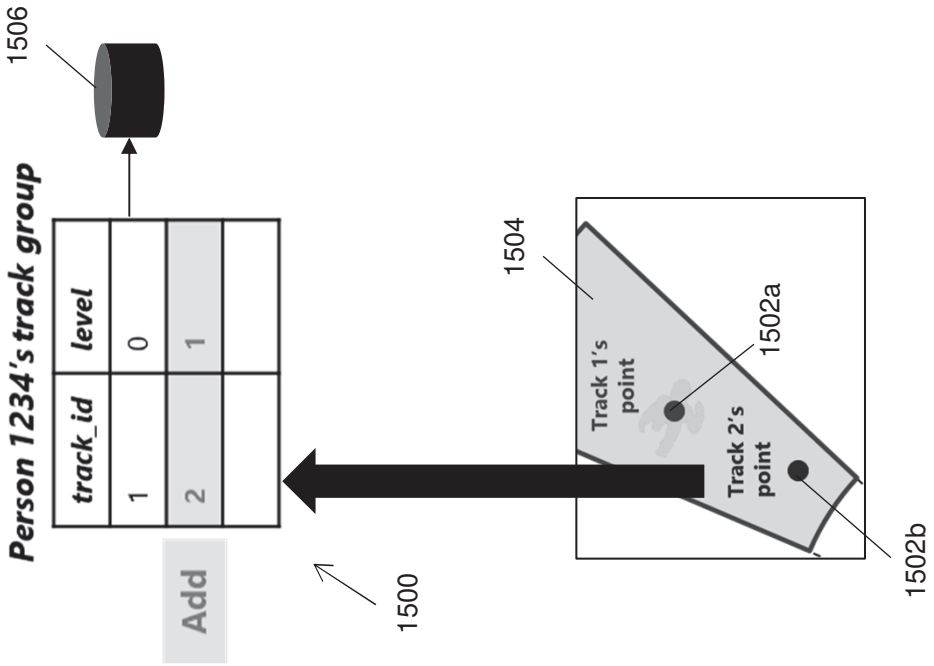


Figure 15A

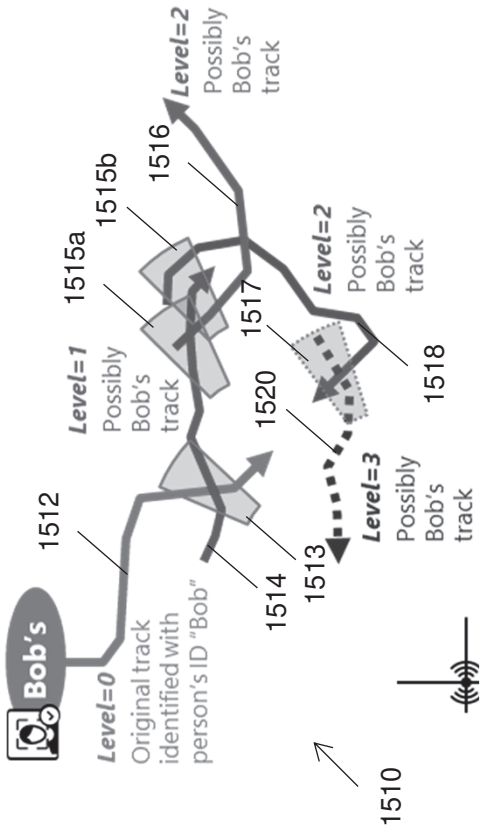


Figure 15B

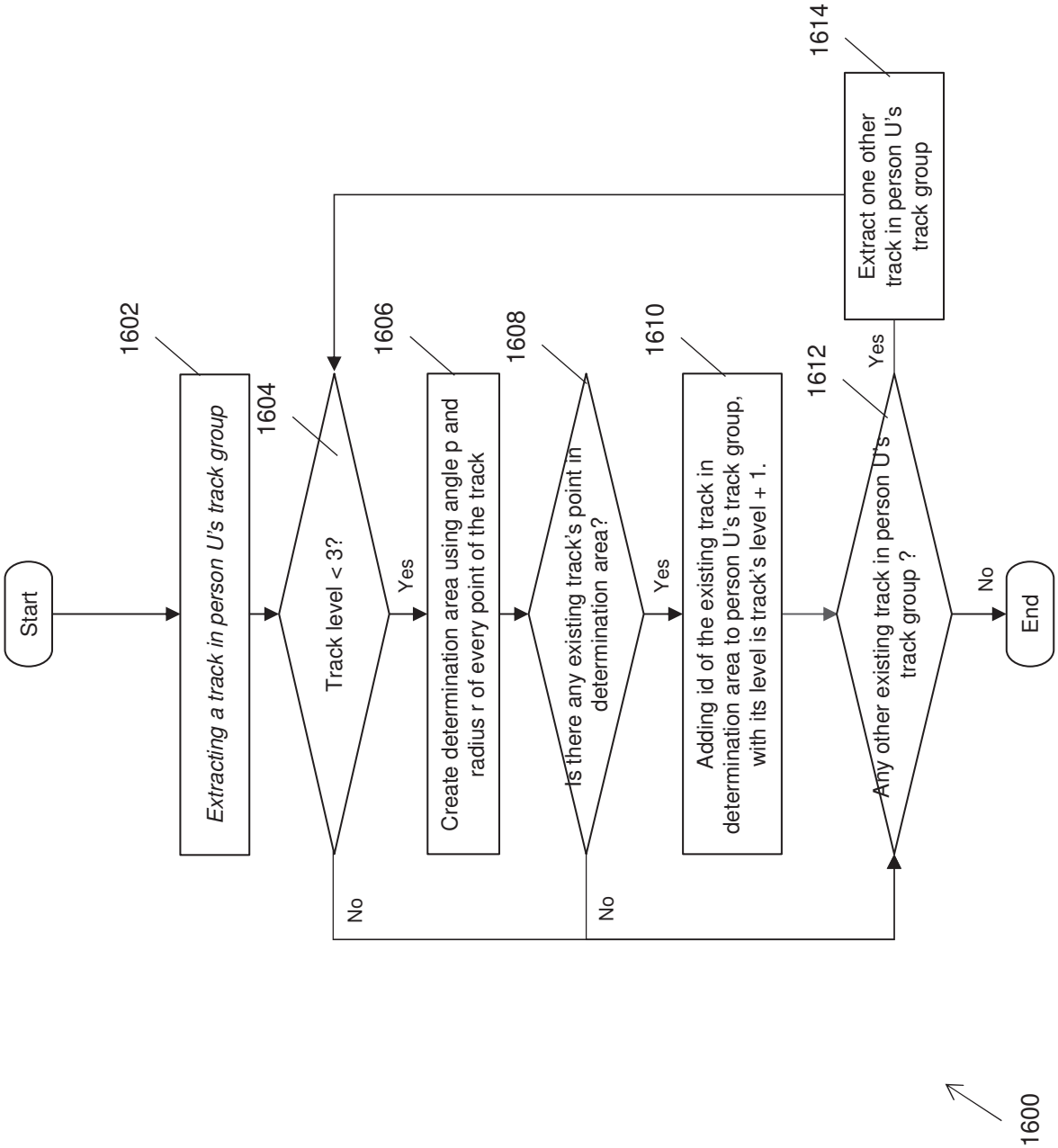

Start
Extracting a track in person U's track group
1602
Track level < 3?
1604
Yes
No
Create determination area using angle p and radius r of every point of the track
1606
Is there any existing track's point in determination area?
1608
Yes
No
Adding id of the existing track in determination area to person U's track group, with its level is track's level + 1.
1610
Any other existing track in person U's track group ?
1612
Yes
No
Extract one other track in person U's track group
1614
End
1600

Figure 16

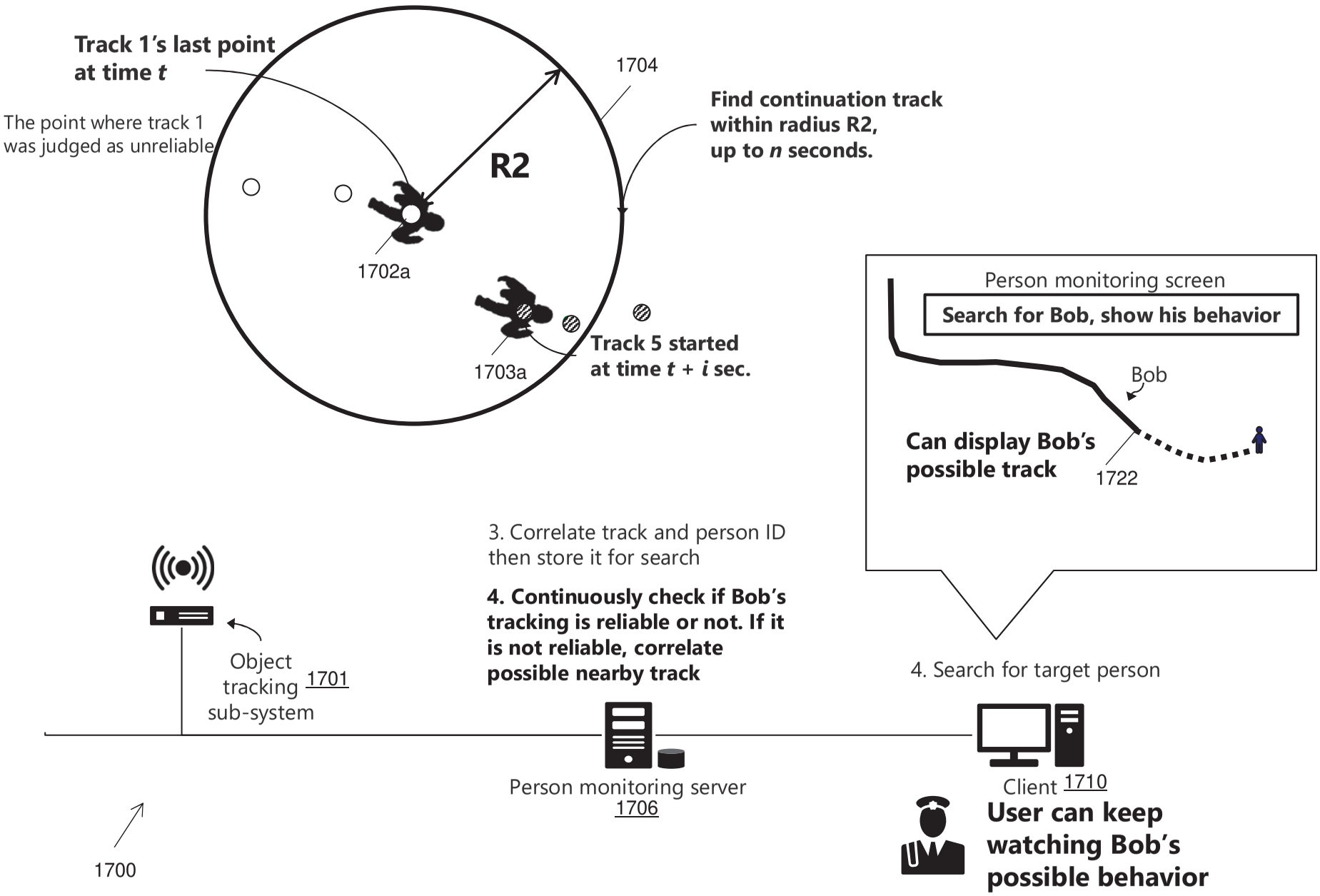

Track 1's last point at time t
The point where track 1 was judged as unreliable
1704
Find continuation track within radius R2, up to n seconds.
R2
1702a
1703a
Track 5 started at time t + i sec.
Person monitoring screen
Search for Bob, show his behavior
Bob
Can display Bob's possible track
1722
3. Correlate track and person ID then store it for search
4. Continuously check if Bob's tracking is reliable or not. If it is not reliable, correlate possible nearby track
4. Search for target person
Object tracking sub-system 1701
Person monitoring server 1706
Client 1710
User can keep watching Bob's possible behavior
1700

Figure 17

Person 1234's track search area list

track_id	*origin (x, y)*	*level*
1	(5.34, 2.35)	0



Figure 18

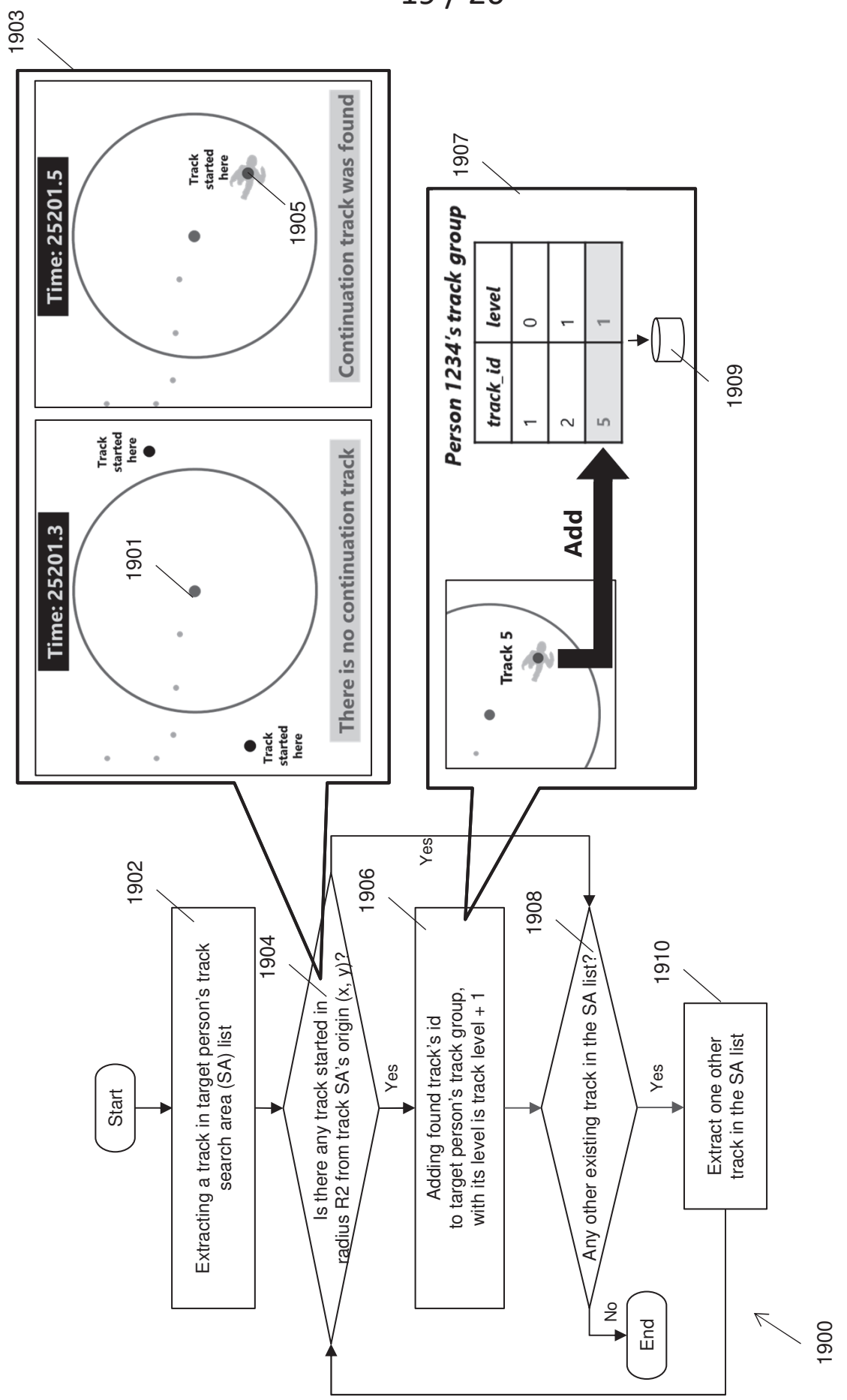

1903
Time: 25201.5
Track started here
1905
Continuation track was found
Time: 25201.3
Track started here
1901
Track started here
There is no continuation track
1907
Person 1234's track group
track_id
level
1
0
2
1
5
1
1909
Track 5
Add
Start
1902
Extracting a track in target person's track search area (SA) list
1904
Is there any track started in radius R2 from track SA's origin (x, y)?
Yes
1906
Adding found track's id to target person's track group, with its level is track level + 1
1908
Any other existing track in the SA list?
Yes
1910
Extract one other track in the SA list
No
End
1900

Figure 19

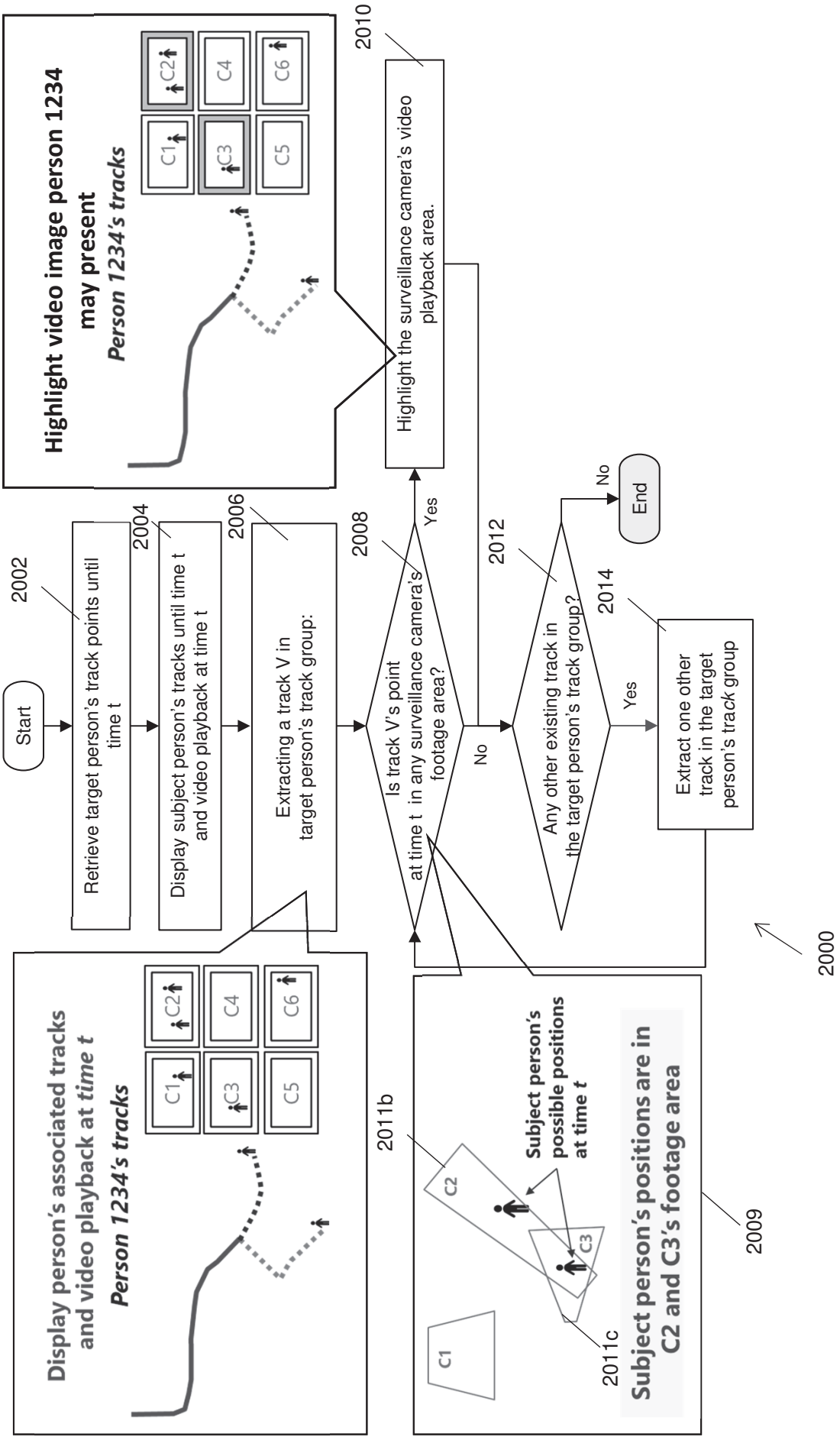

Start
2002
Retrieve target person's track points until time t
2004
Display subject person's tracks until time t and video playback at time t
2006
Extracting a track V in target person's track group:
2008
Is track V's point at time t in any surveillance camera's footage area?
Yes
No
2010
Highlight the surveillance camera's video playback area.
2012
Any other existing track in the target person's track group?
Yes
No
End
2014
Extract one other track in the target person's track group
Highlight video image person 1234 may present Person 1234's tracks
C1
C2
C3
C4
C5
C6
Display person's associated tracks and video playback at time t Person 1234's tracks
2011b
Subject person's possible positions at time t
2011c
Subject person's positions are in C2 and C3's footage area
2009
2000

Figure 20

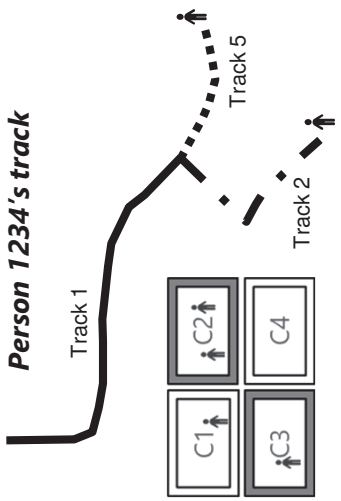


Figure 21B

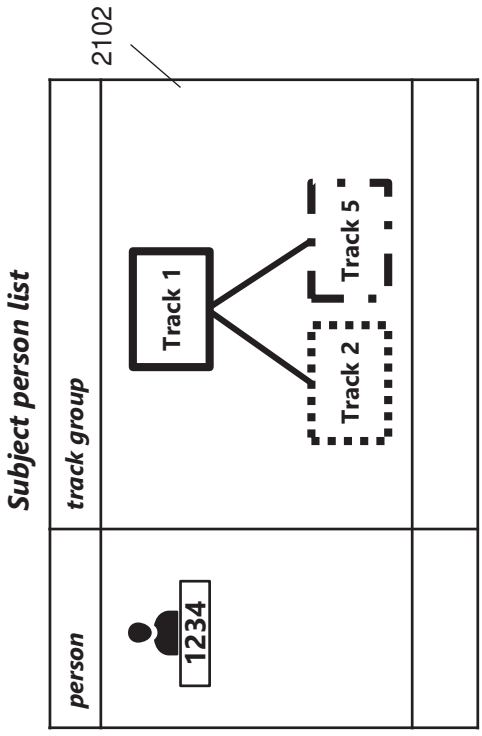


Figure 21A

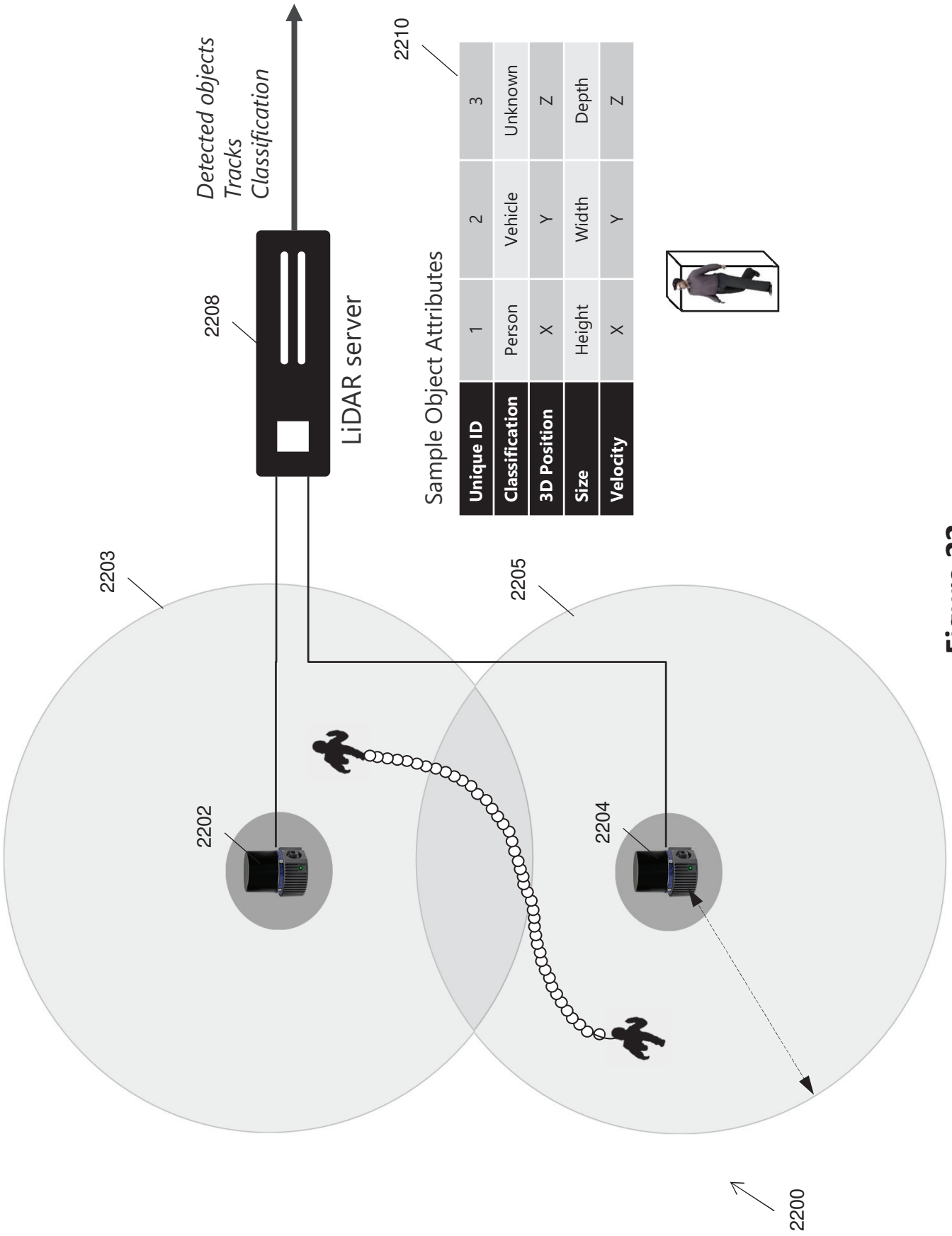

2200
2202
2203
2204
2205
2208
LiDAR server
Detected objects
Tracks
Classification
2210
Sample Object Attributes
Unique ID
Classification
3D Position
Size
Velocity
1
Person
X
Height
X
2
Vehicle
Y
Width
Y
3
Unknown
Z
Depth
Z

Figure 22

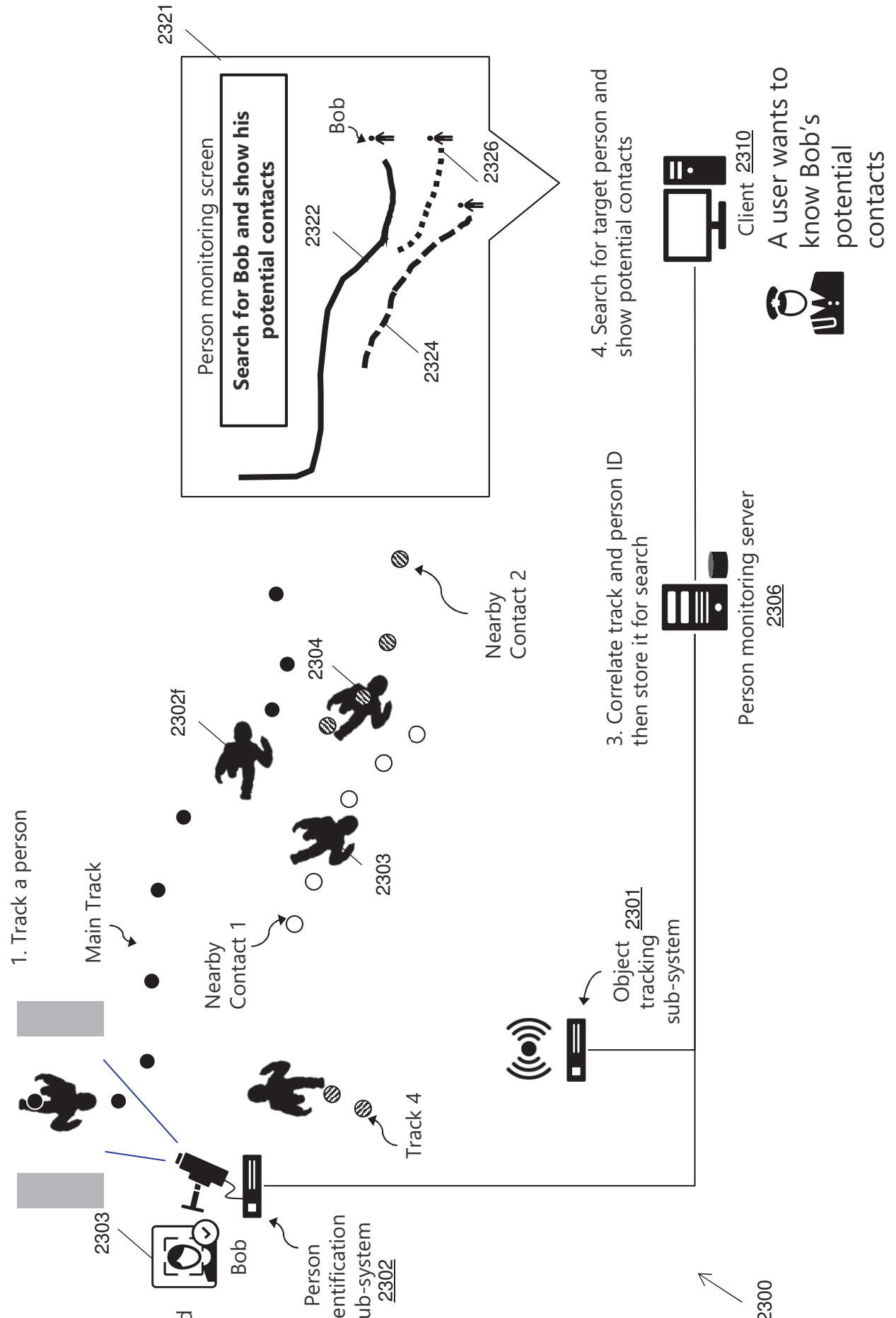

2321
Person monitoring screen
Search for Bob and show his potential contacts
Bob
2322
2326
2324
4. Search for target person and show potential contacts
Client 2310
A user wants to know Bob's potential contacts
Nearby Contact 2
2304
2302f
2303
Nearby Contact 1
Main Track
1. Track a person
3. Correlate track and person ID then store it for search
Person monitoring server 2306
Object tracking sub-system 2301
Track 4
2303
Bob
Person identification sub-system 2302
2.Identify the tracked person.
2300

Figure 23

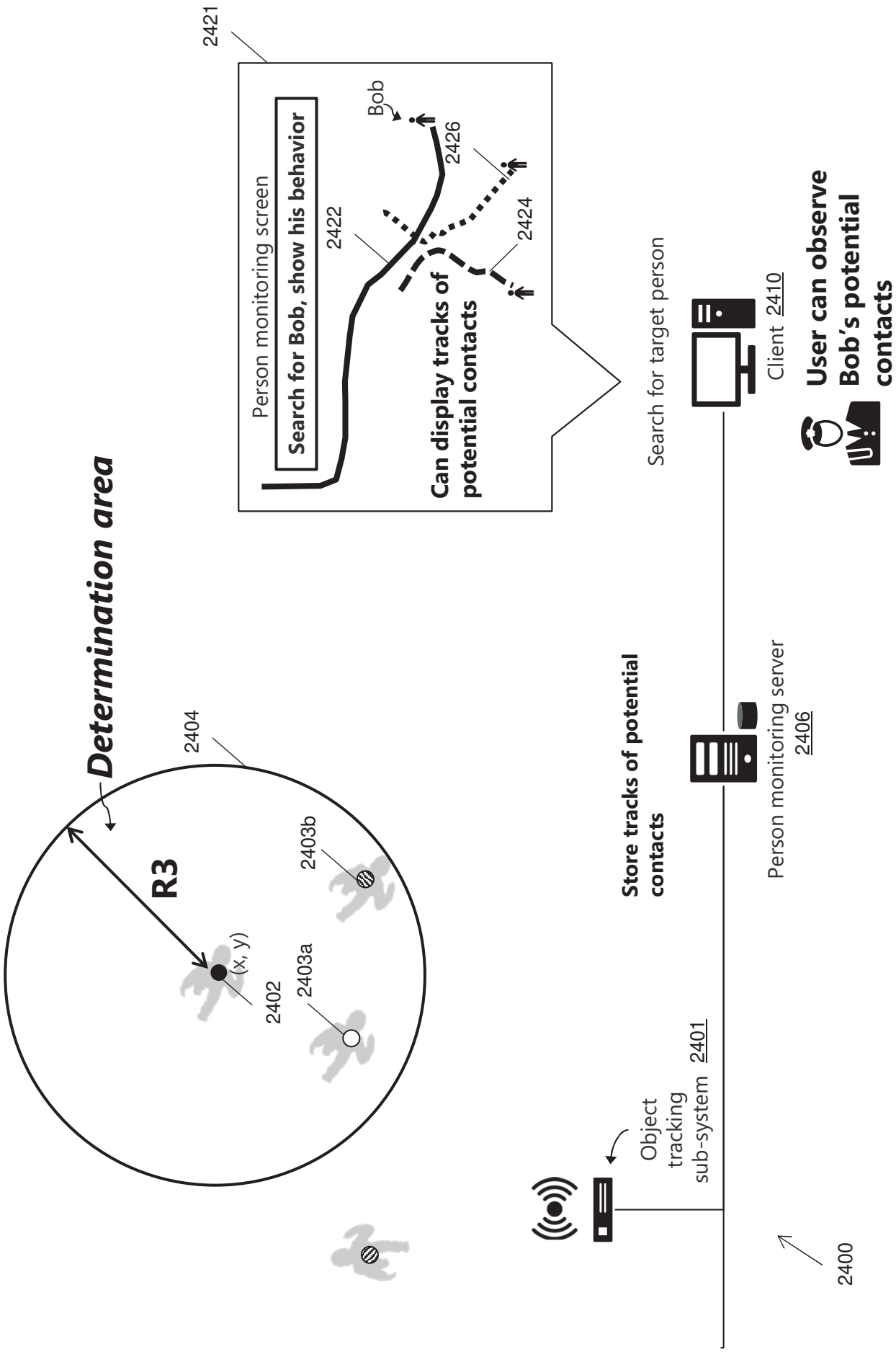

2421
Person monitoring screen
Search for Bob, show his behavior
2422
Bob
2426
2424
Can display tracks of potential contacts
Search for target person
Client 2410
User can observe Bob's potential contacts
Determination area
2404
R3
(x, y)
2402
2403a
2403b
Store tracks of potential contacts
Person monitoring server 2406
Object tracking sub-system 2401
2400

Figure 24

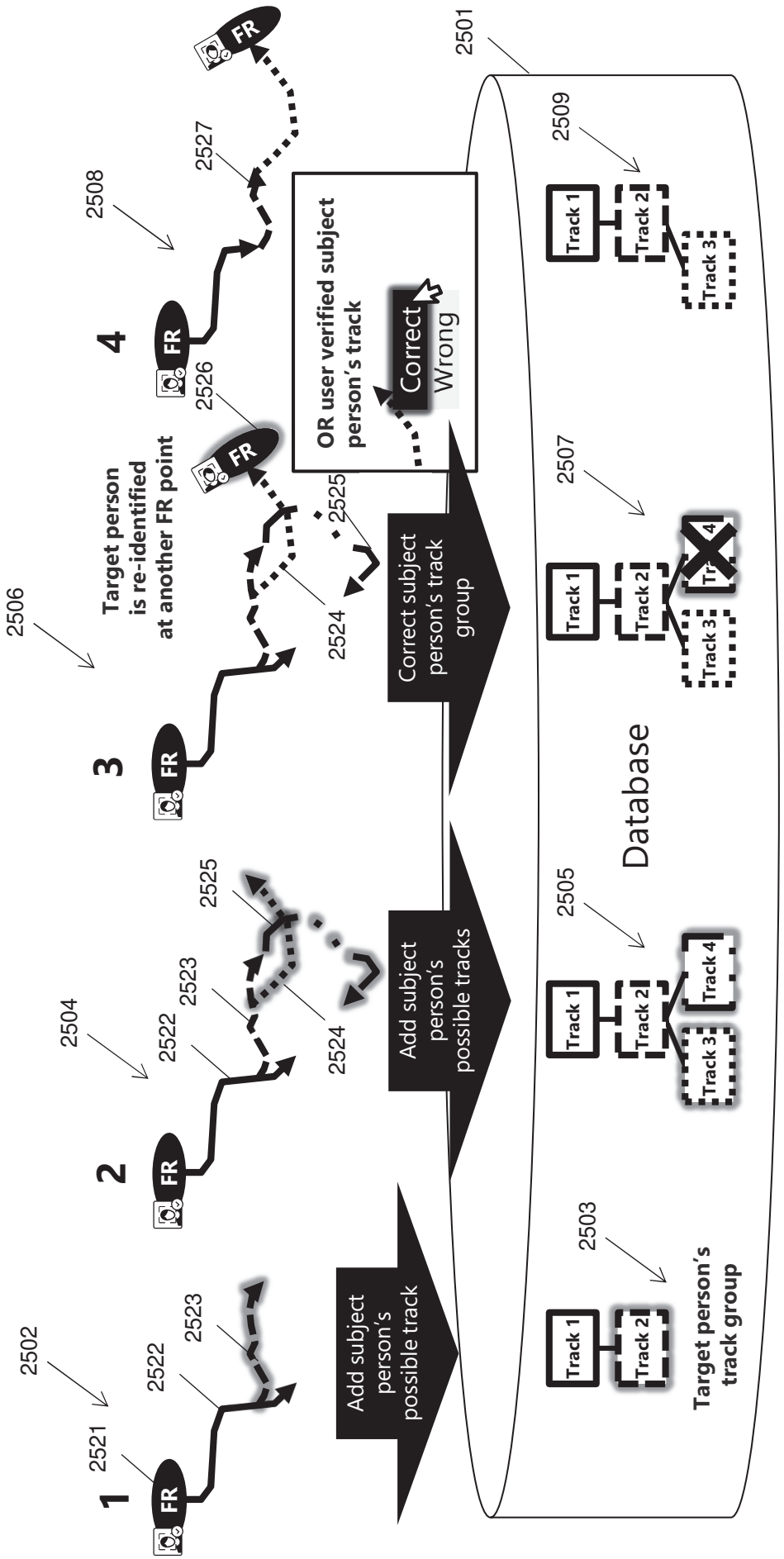

1
2
3
4
FR
2500
2501
2502
2503
2504
2505
2506
2507
2508
2509
2521
2522
2523
2524
2525
2526
2527
Add subject person's possible track
Add subject person's possible tracks
Correct subject person's track group
Target person is re-identified at another FR point
OR user verified subject person's track
Correct
Wrong
Database
Target person's track group
Track 1
Track 2
Track 3
Track 4

Figure 25

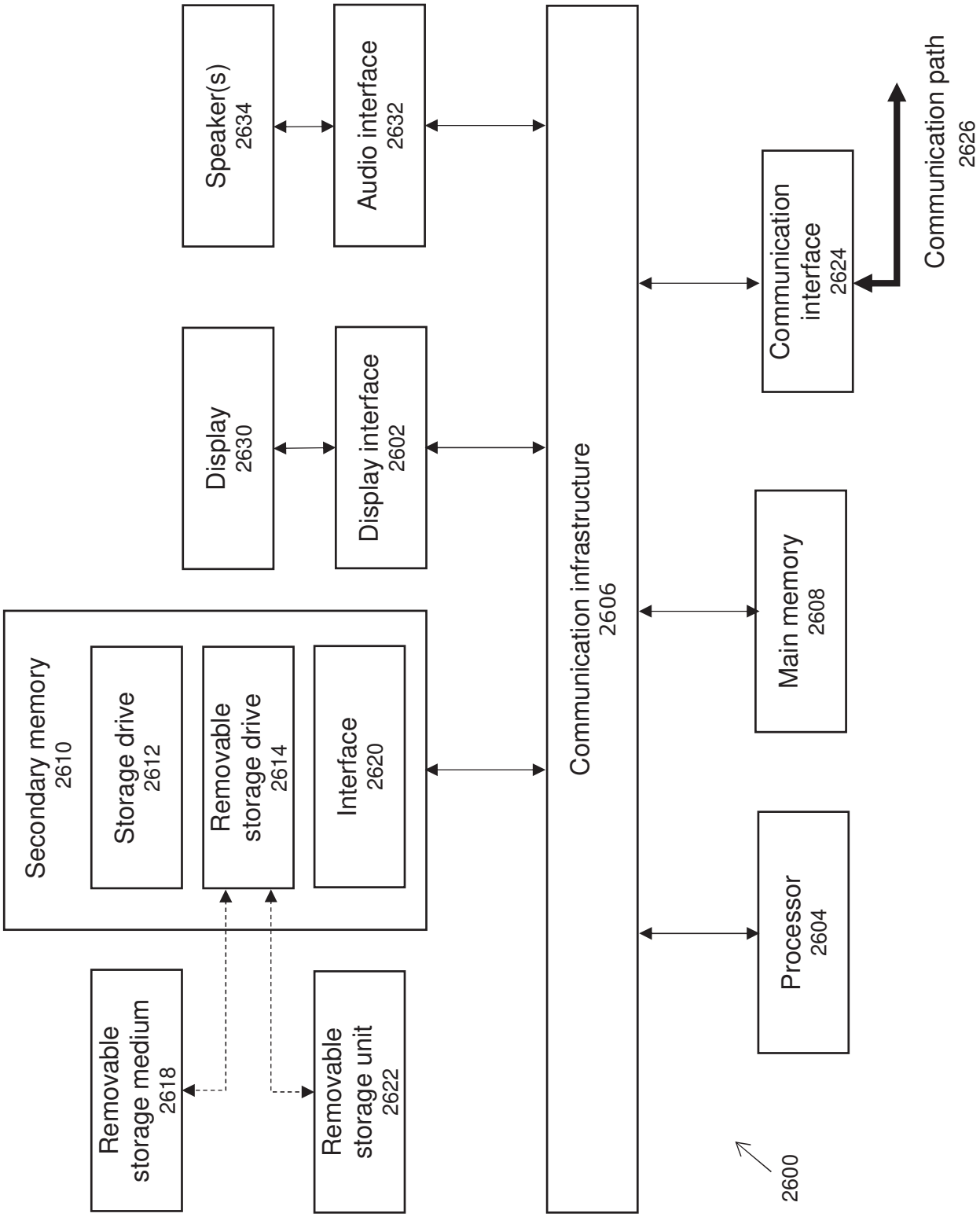

Speaker(s)
2634
Audio interface
2632
Display
2630
Display interface
2602
Secondary memory
2610
Storage drive
2612
Removable storage drive
2614
Interface
2620
Communication infrastructure
2606
Communication interface
2624
Communication path
2626
Main memory
2608
Removable storage medium
2618
Removable storage unit
2622
Processor
2604
2600

Figure 26