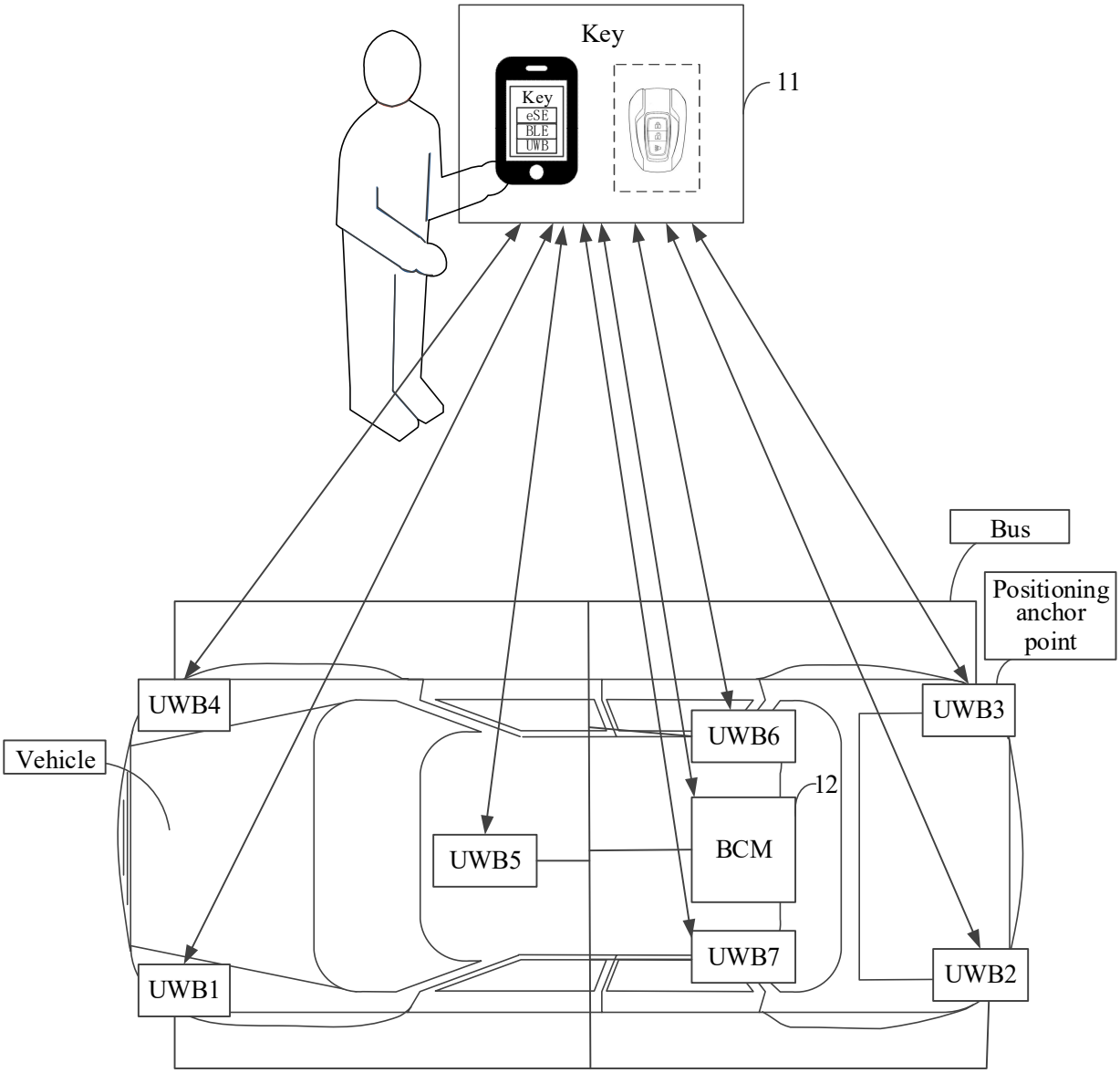

Key
Key
eSE
BLE
UWB
11
Bus
Positioning anchor point
UWB4
UWB3
Vehicle
UWB6
12
BCM
UWB5
UWB7
UWB1
UWB2

FIG. 1a

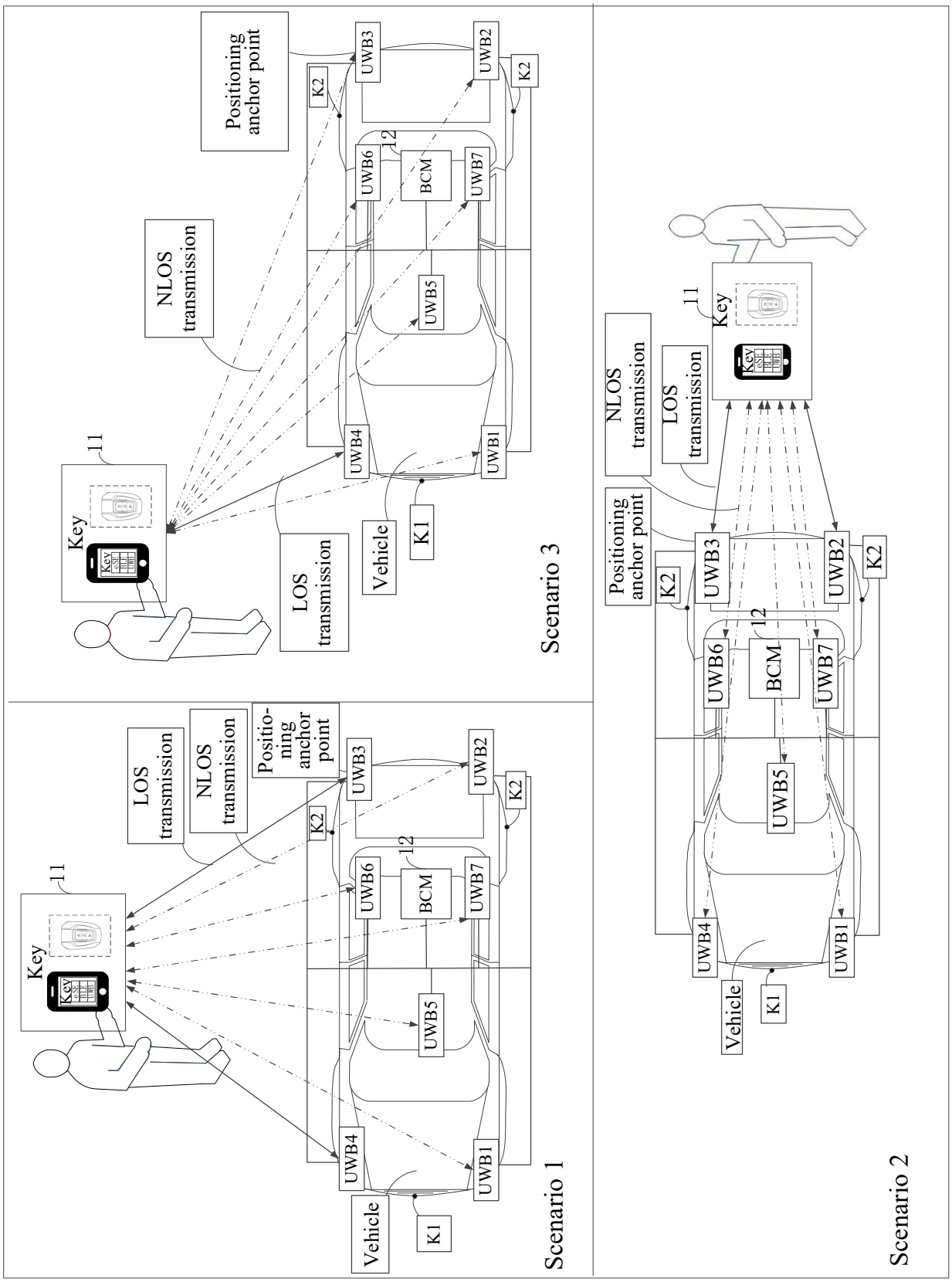

Scenario 1
Key
11
LOS transmission
NLOS transmission
Positio-ning anchor point
UWB3
UWB2
K2
12
UWB6
BCM
UWB7
UWB5
UWB4
UWB1
Vehicle
K1
Scenario 3
Positioning anchor point
NLOS transmission
LOS transmission
Scenario 2

FIG. 1b

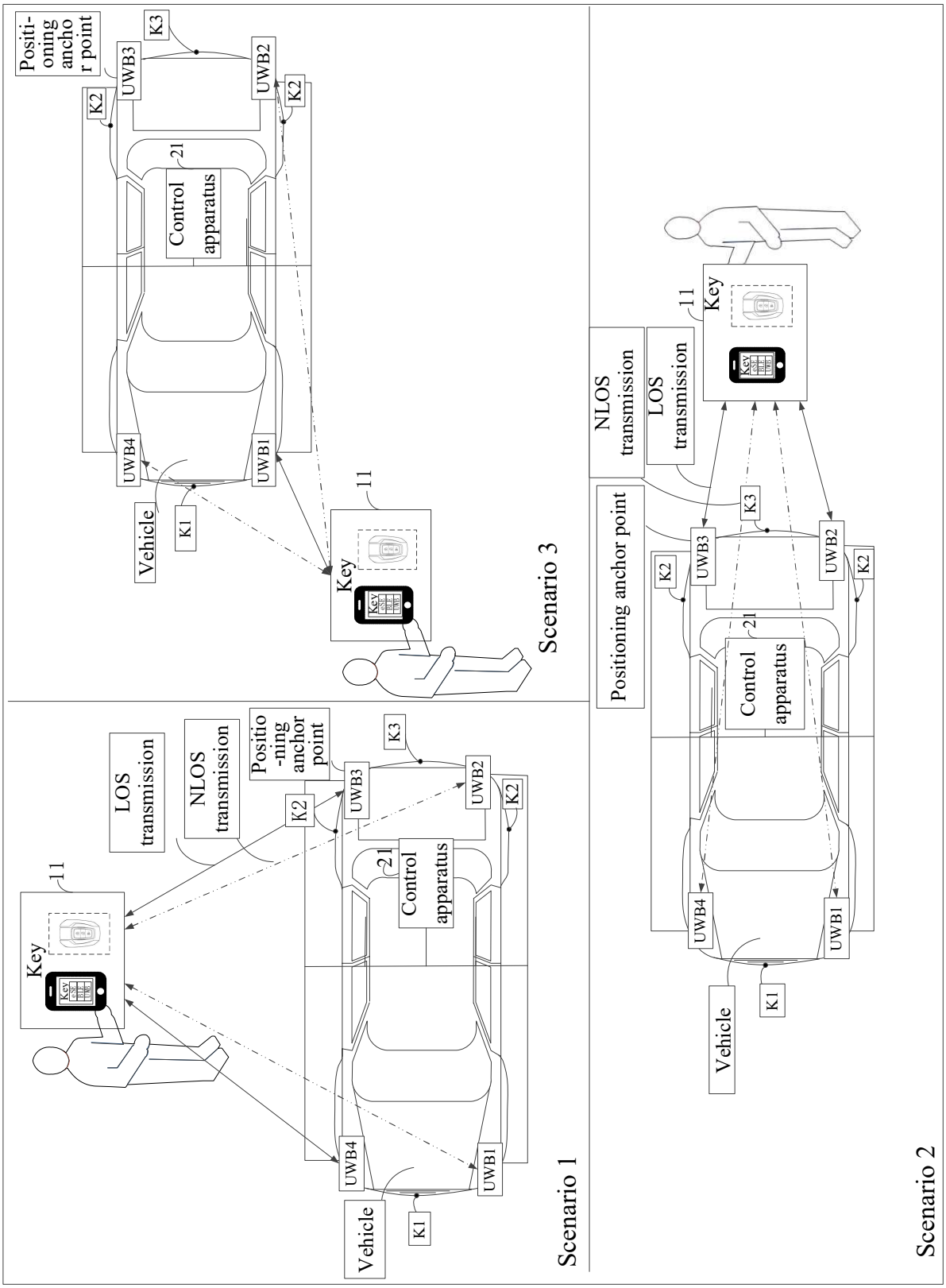

Scenario 1
Key
11
LOS transmission
NLOS transmission
Positio-ning anchor point
K2
UWB3
K3
UWB2
21
Control apparatus
UWB4
UWB1
Vehicle
K1
Scenario 2
Positioning anchor point
NLOS transmission
LOS transmission
Scenario 3
Positi-oning ancho r point

FIG. 2

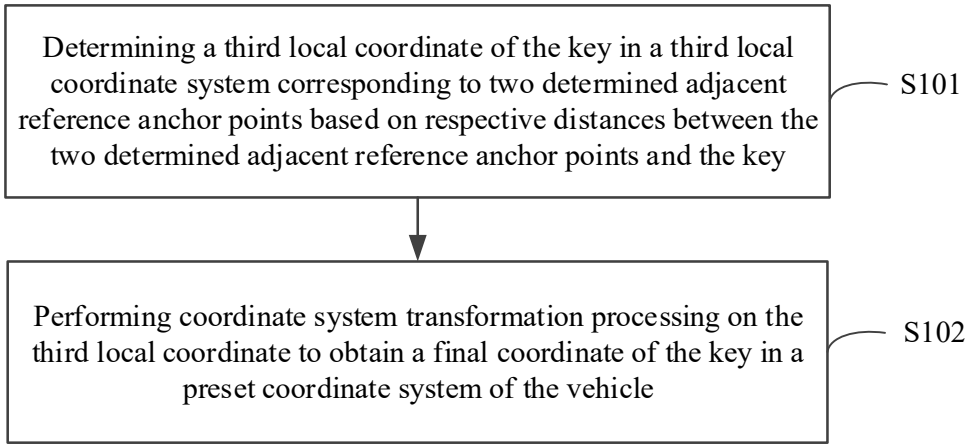

Determining a third local coordinate of the key in a third local coordinate system corresponding to two determined adjacent reference anchor points based on respective distances between the two determined adjacent reference anchor points and the key
S101
Performing coordinate system transformation processing on the third local coordinate to obtain a final coordinate of the key in a preset coordinate system of the vehicle
S102

FIG. 3

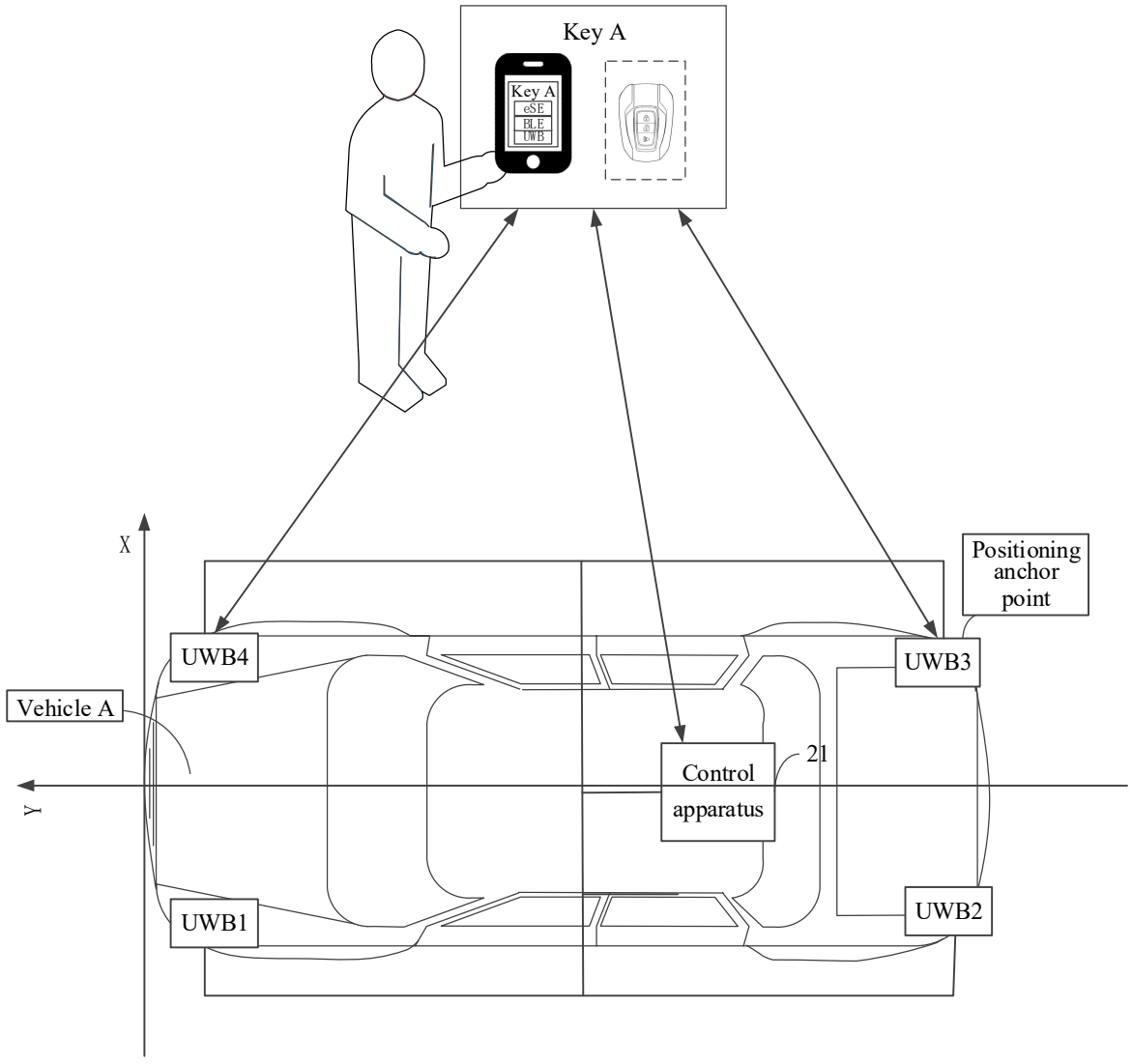

Key A
Key A
eSE
BLE
UWB
X
Y
Positioning anchor point
UWB4
UWB3
Vehicle A
Control apparatus
21
UWB1
UWB2

FIG. 4

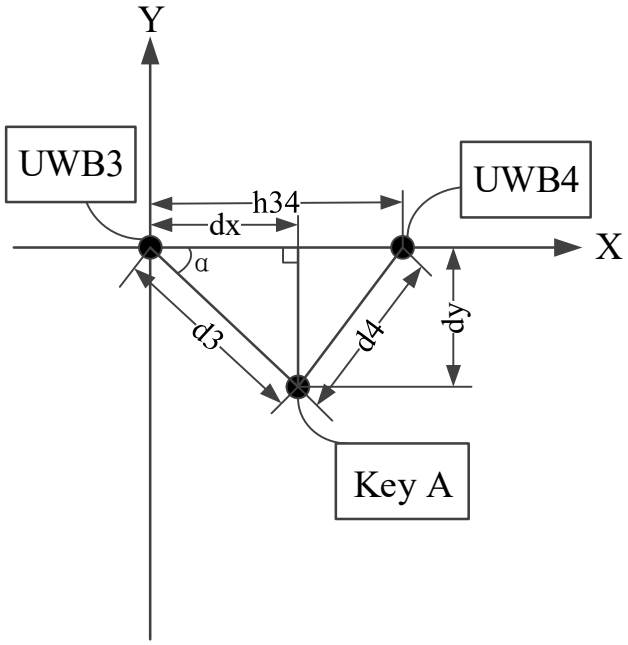

Y
UWB3
UWB4
h34
dx
X
α
d3
d4
dy
Key A

FIG. 5

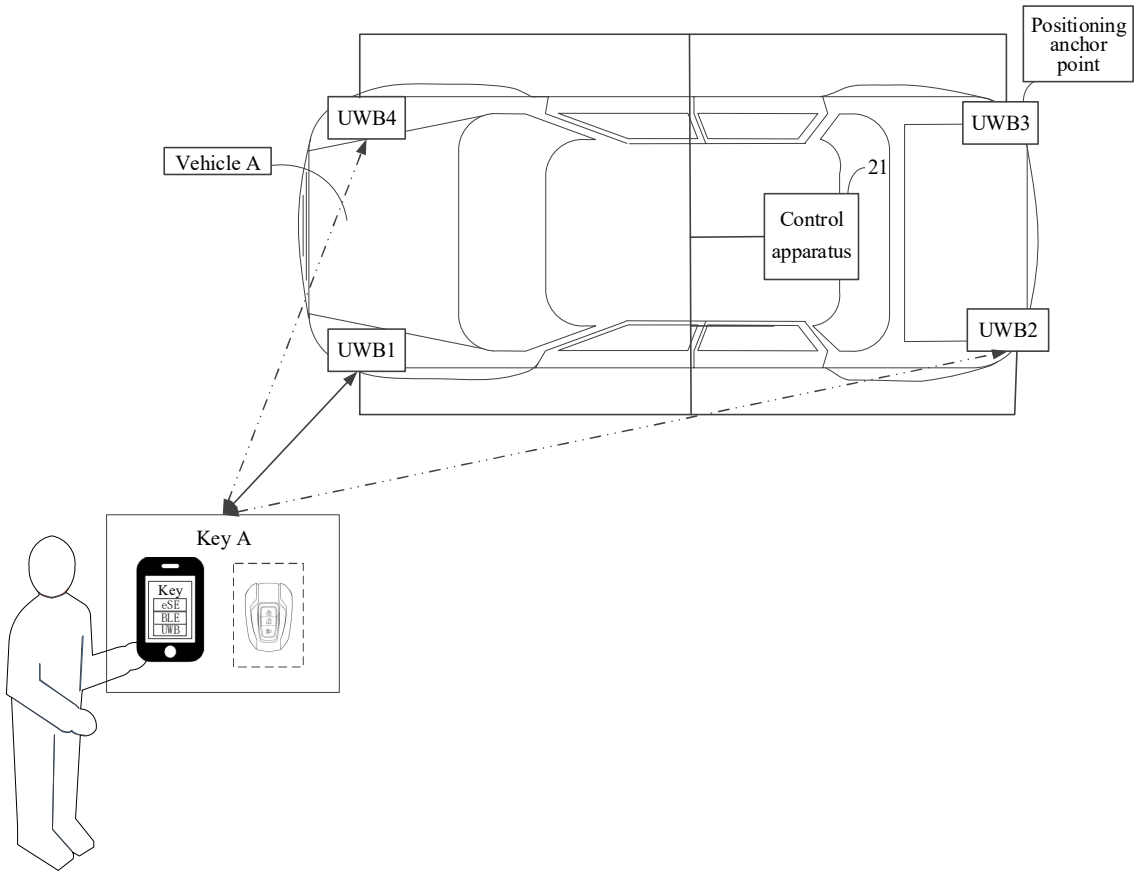

Positioning anchor point
UWB4
UWB3
Vehicle A
21
Control apparatus
UWB1
UWB2
Key A
Key
eSE
BLE
UWB

FIG. 6

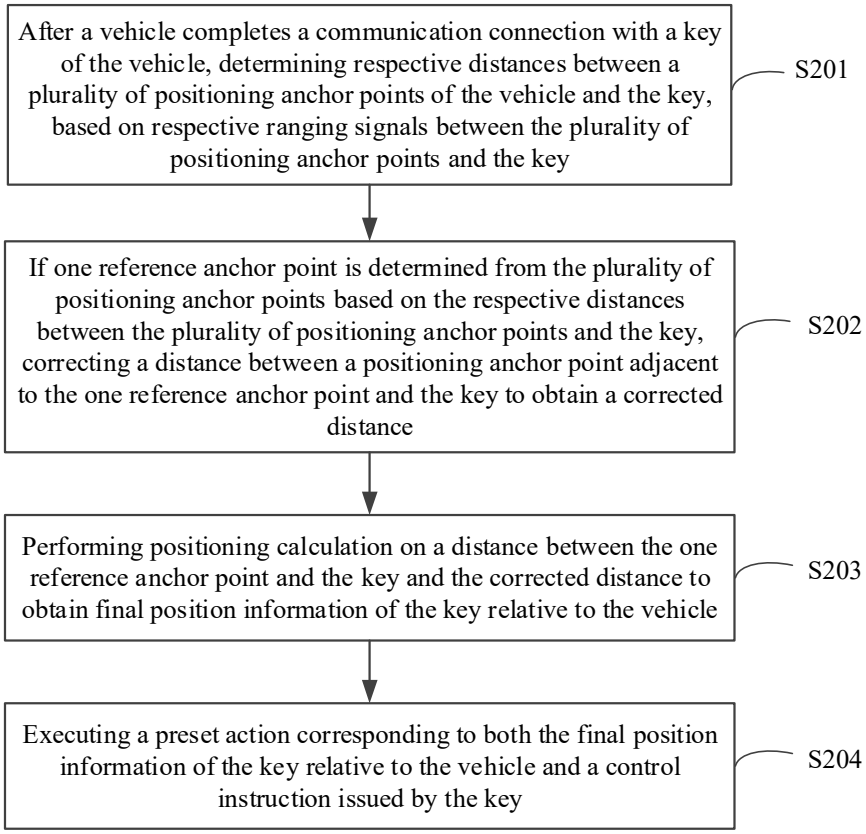

After a vehicle completes a communication connection with a key of the vehicle, determining respective distances between a plurality of positioning anchor points of the vehicle and the key, based on respective ranging signals between the plurality of positioning anchor points and the key
S201
If one reference anchor point is determined from the plurality of positioning anchor points based on the respective distances between the plurality of positioning anchor points and the key, correcting a distance between a positioning anchor point adjacent to the one reference anchor point and the key to obtain a corrected distance
S202
Performing positioning calculation on a distance between the one reference anchor point and the key and the corrected distance to obtain final position information of the key relative to the vehicle
S203
Executing a preset action corresponding to both the final position information of the key relative to the vehicle and a control instruction issued by the key
S204

FIG. 7

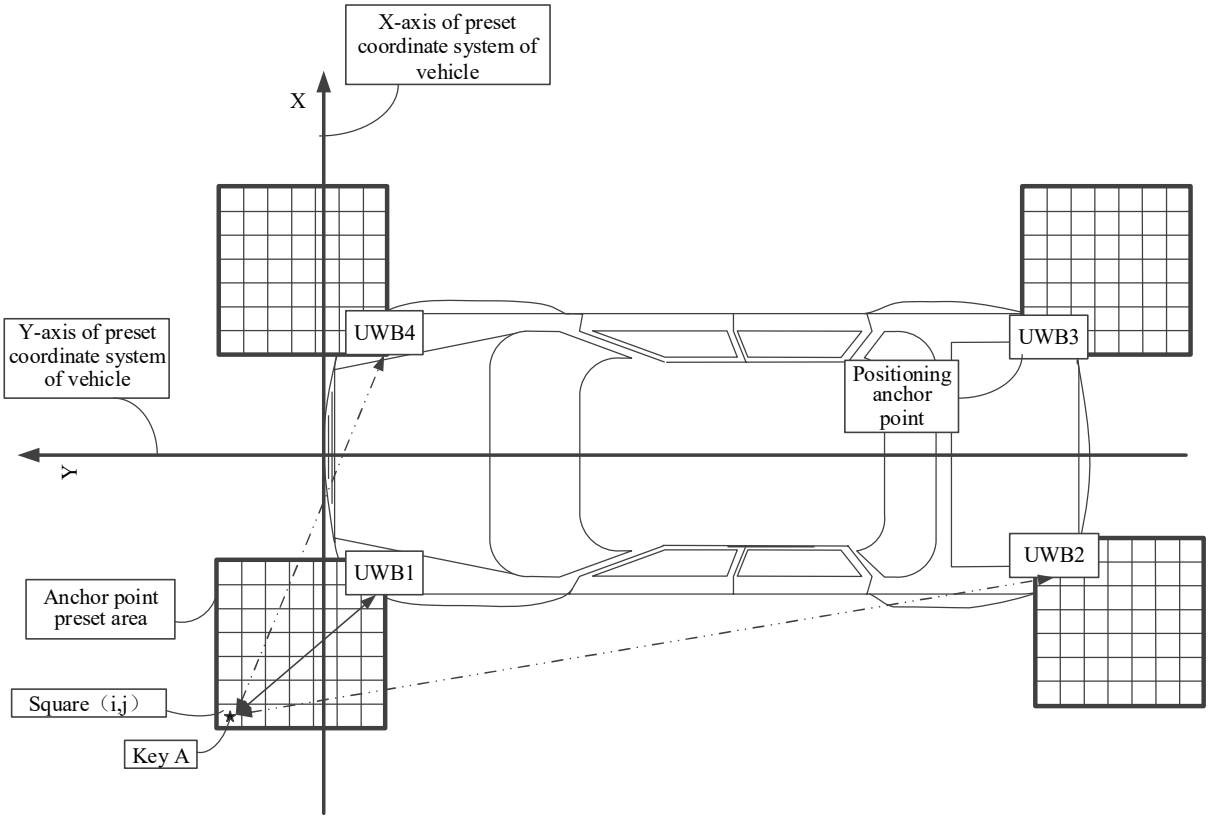

X-axis of preset coordinate system of vehicle
X
Y-axis of preset coordinate system of vehicle
Y
UWB4
UWB3
Positioning anchor point
UWB1
UWB2
Anchor point preset area
Square（i,j）
Key A

FIG. 8

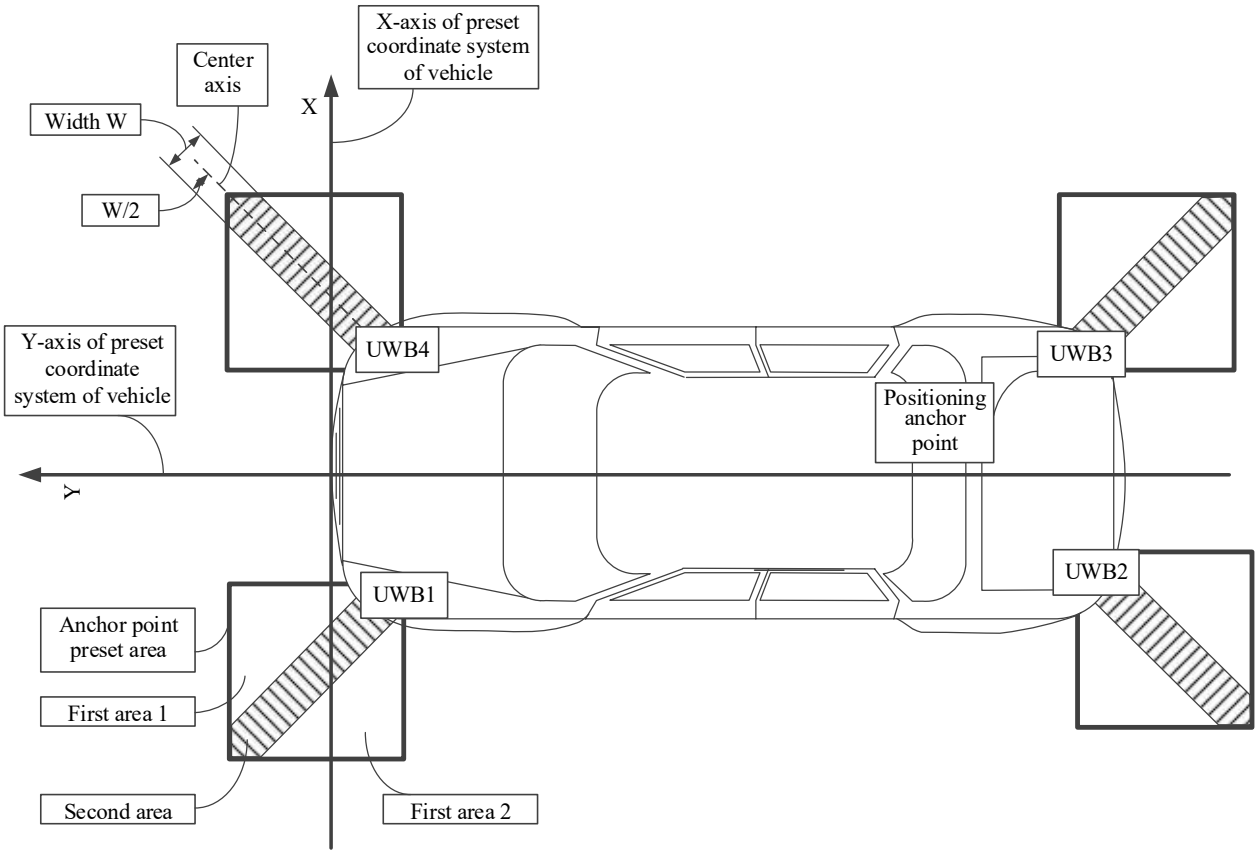

X-axis of preset coordinate system of vehicle
Center axis
X
Width W
W/2
Y-axis of preset coordinate system of vehicle
Y
UWB4
UWB3
Positioning anchor point
UWB1
UWB2
Anchor point preset area
First area 1
Second area
First area 2

FIG. 9

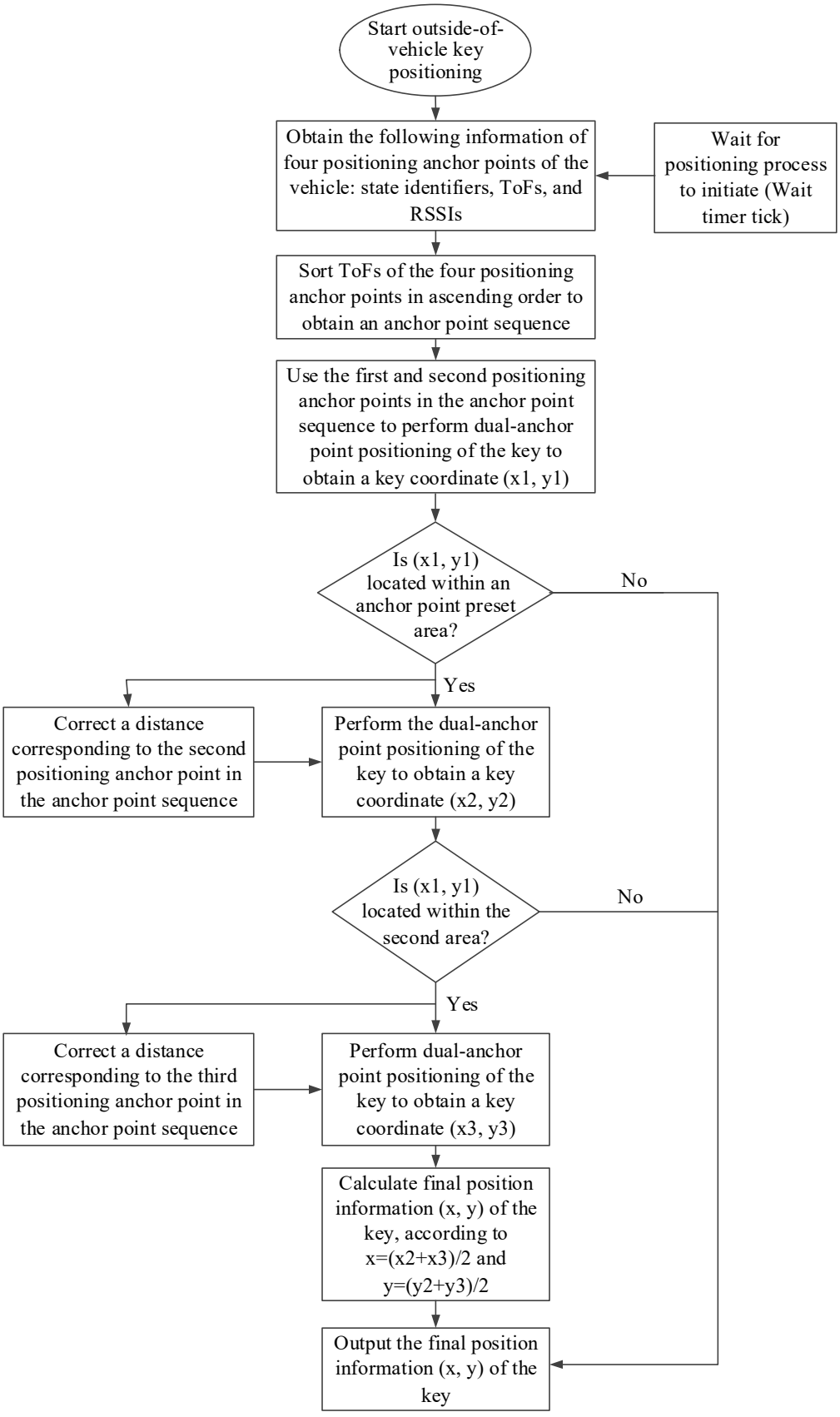

Start outside-of-vehicle key positioning
Obtain the following information of four positioning anchor points of the vehicle: state identifiers, ToFs, and RSSIs
Wait for positioning process to initiate (Wait timer tick)
Sort ToFs of the four positioning anchor points in ascending order to obtain an anchor point sequence
Use the first and second positioning anchor points in the anchor point sequence to perform dual-anchor point positioning of the key to obtain a key coordinate (x1, y1)
Is (x1, y1) located within an anchor point preset area?
No
Yes
Correct a distance corresponding to the second positioning anchor point in the anchor point sequence
Perform the dual-anchor point positioning of the key to obtain a key coordinate (x2, y2)
Is (x1, y1) located within the second area?
No
Yes
Correct a distance corresponding to the third positioning anchor point in the anchor point sequence
Perform dual-anchor point positioning of the key to obtain a key coordinate (x3, y3)
Calculate final position information (x, y) of the key, according to x=(x2+x3)/2 and y=(y2+y3)/2
Output the final position information (x, y) of the key

FIG. 10

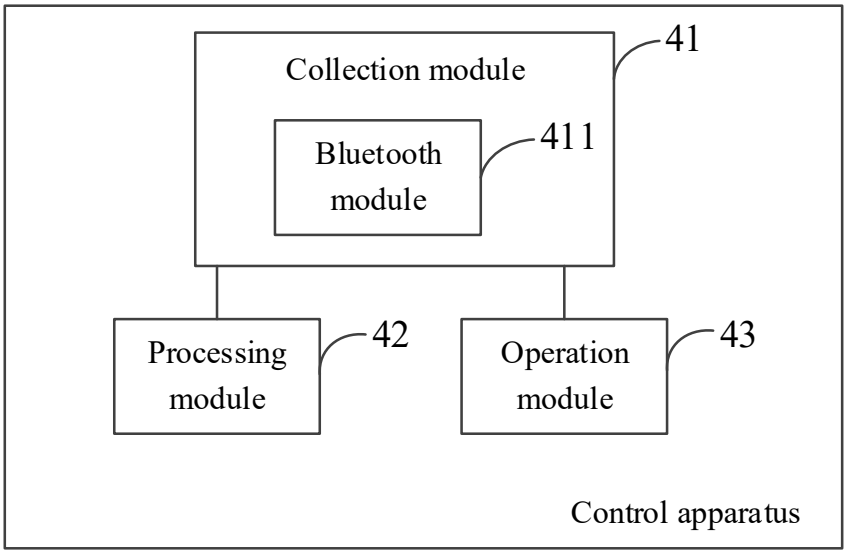

Collection module
41
Bluetooth module
411
Processing module
42
Operation module
43
Control apparatus

FIG. 11

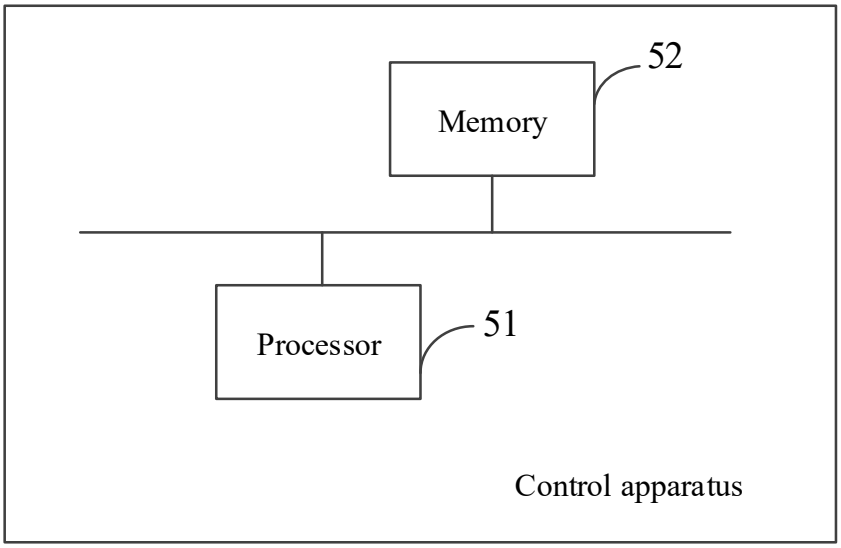

Memory
52
Processor
51
Control apparatus

FIG. 12