FIG. 1

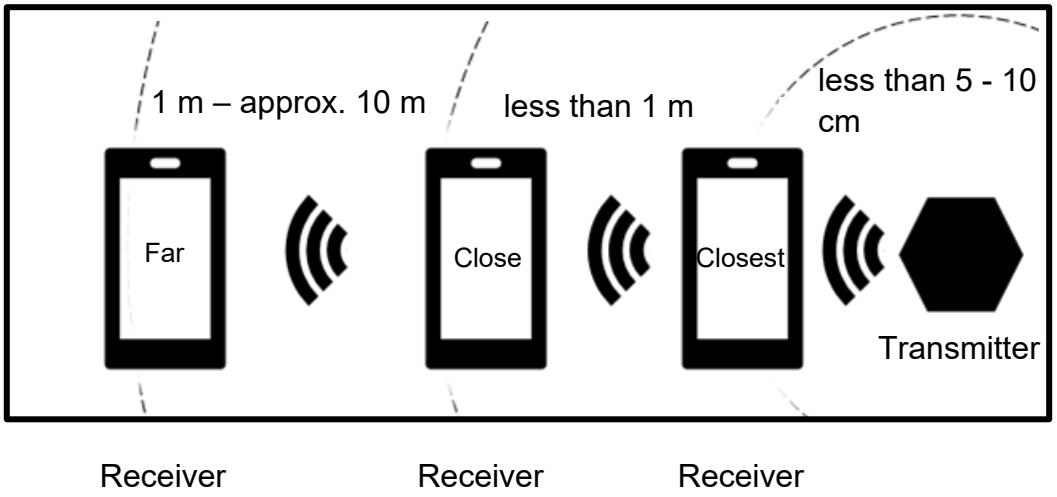

1 m – approx. 10 m
less than 1 m
less than 5 - 10 cm
Far
Close
Closest
Transmitter
Receiver
Receiver
Receiver

FIG. 2

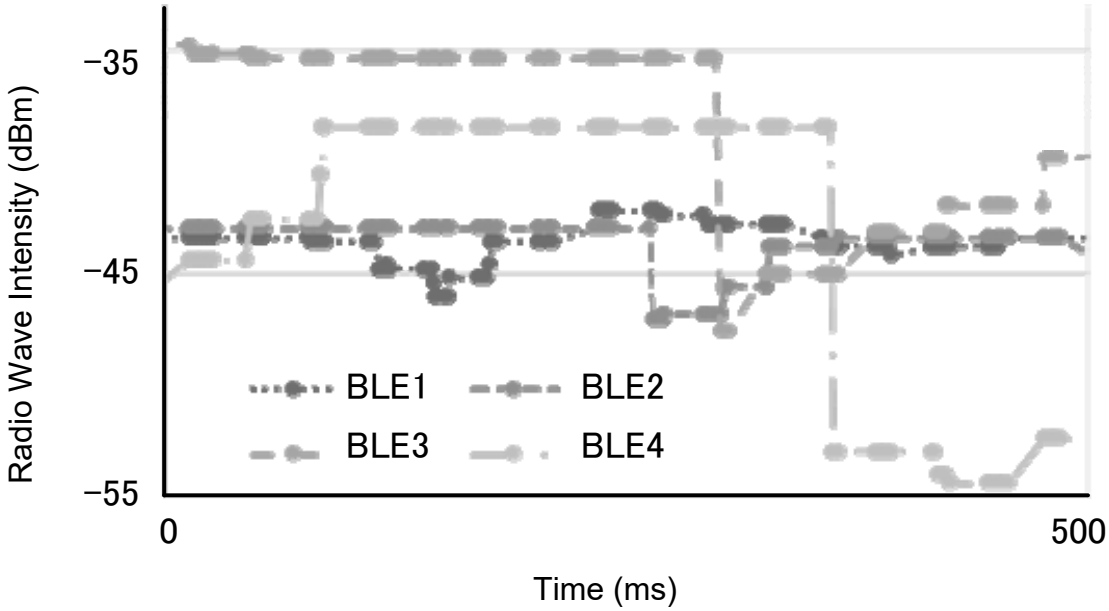

Radio Wave Intensity (dBm)
−35
−45
−55
BLE1
BLE2
BLE3
BLE4
0
500
Time (ms)

FIG. 3

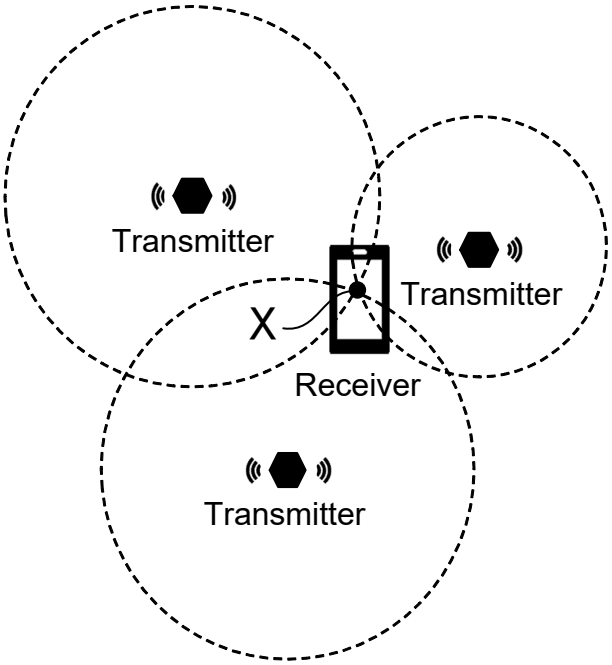

Transmitter
Transmitter
X
Receiver
Transmitter

FIG. 4

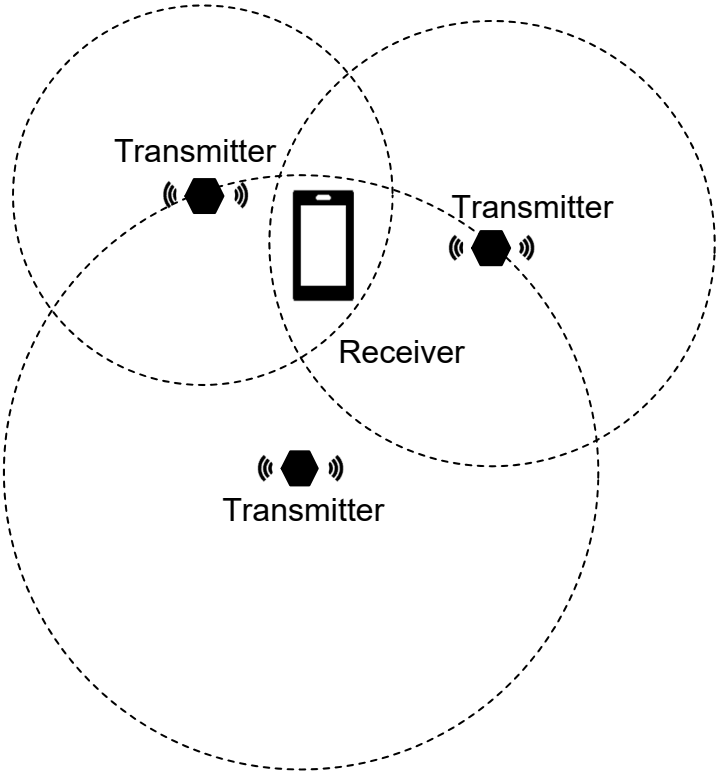

Transmitter
Transmitter
Receiver
Transmitter

FIG. 5

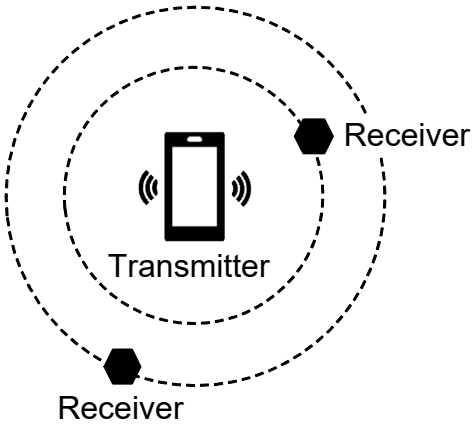

Receiver
Transmitter
Receiver

FIG. 6

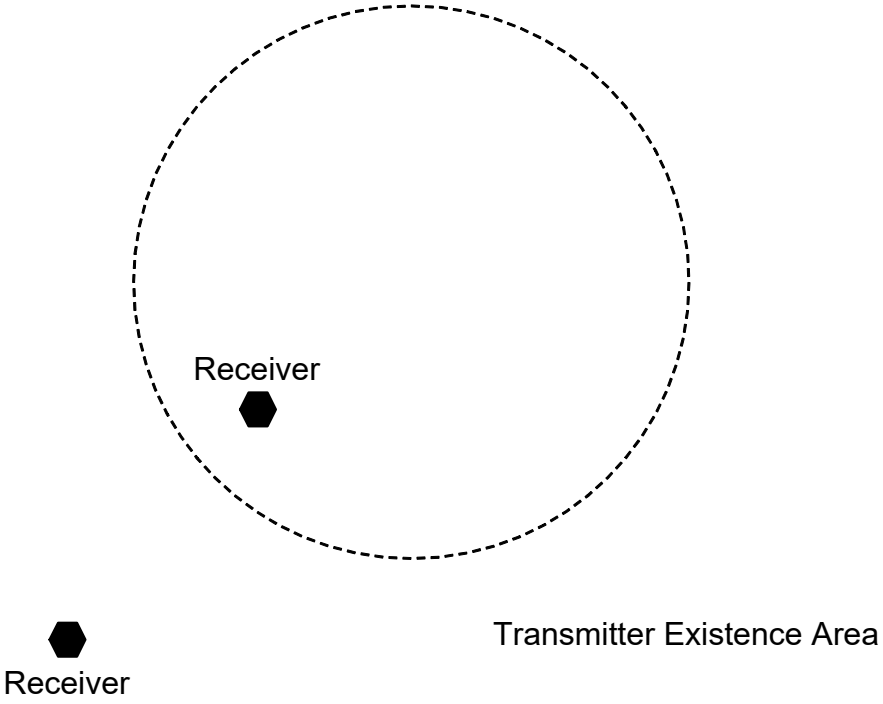

Receiver
Receiver
Transmitter Existence Area

FIG. 7

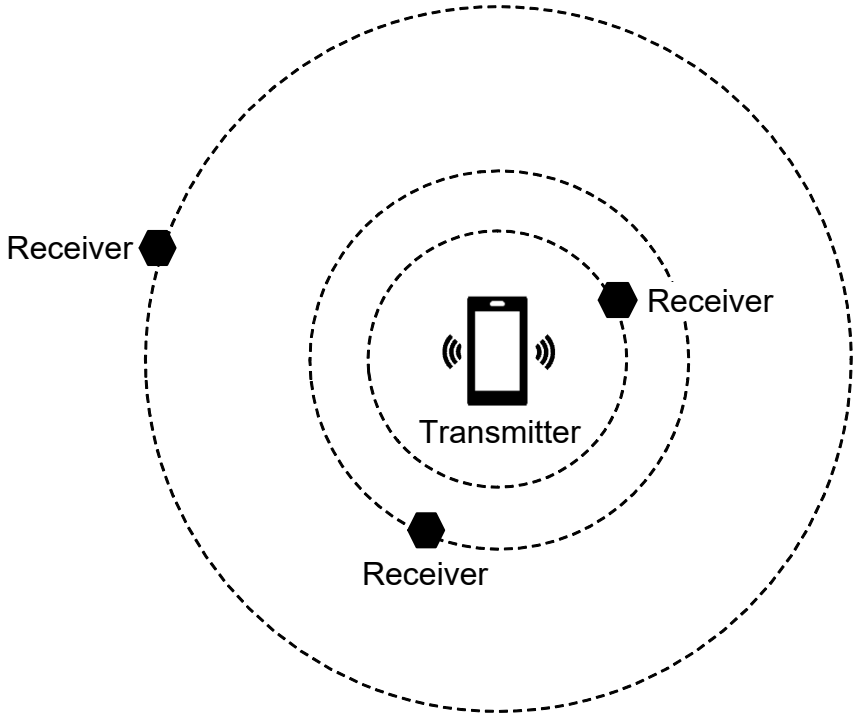

Receiver
Receiver
Transmitter
Receiver

FIG. 8

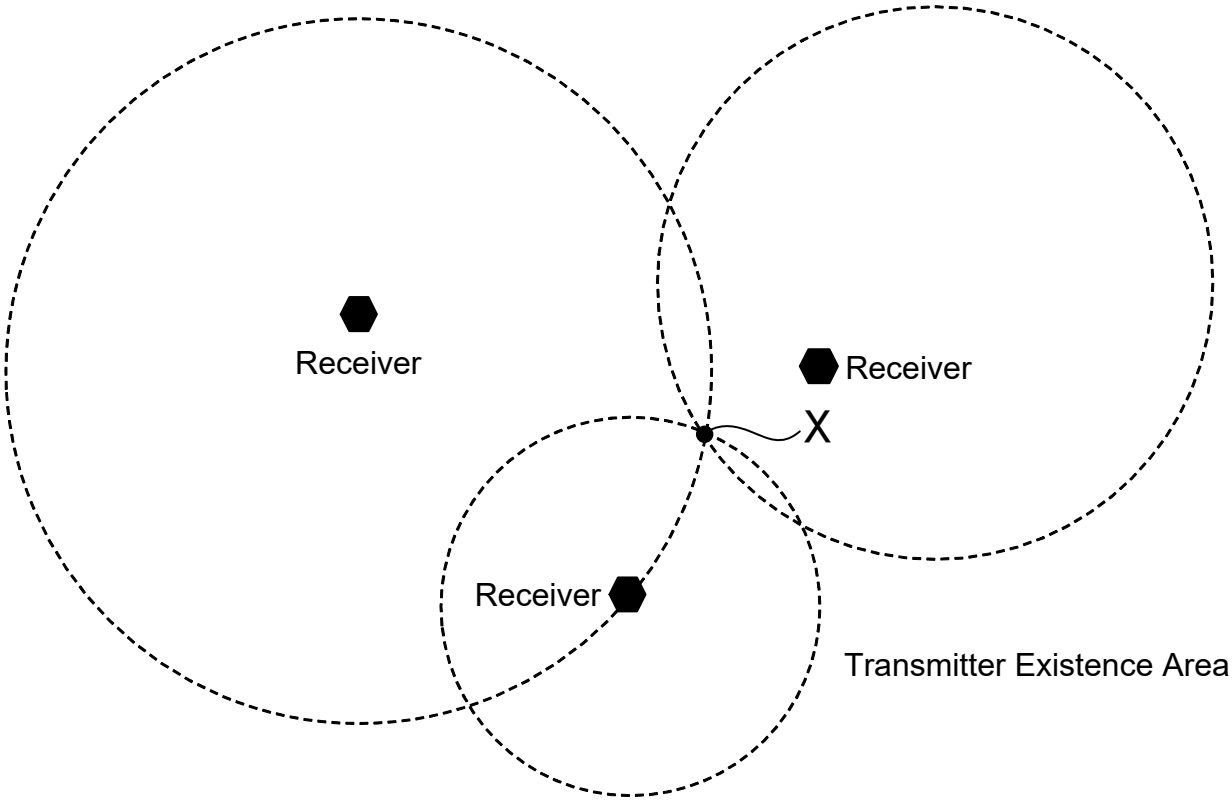

Receiver
Receiver
X
Receiver
Transmitter Existence Area

FIG. 9

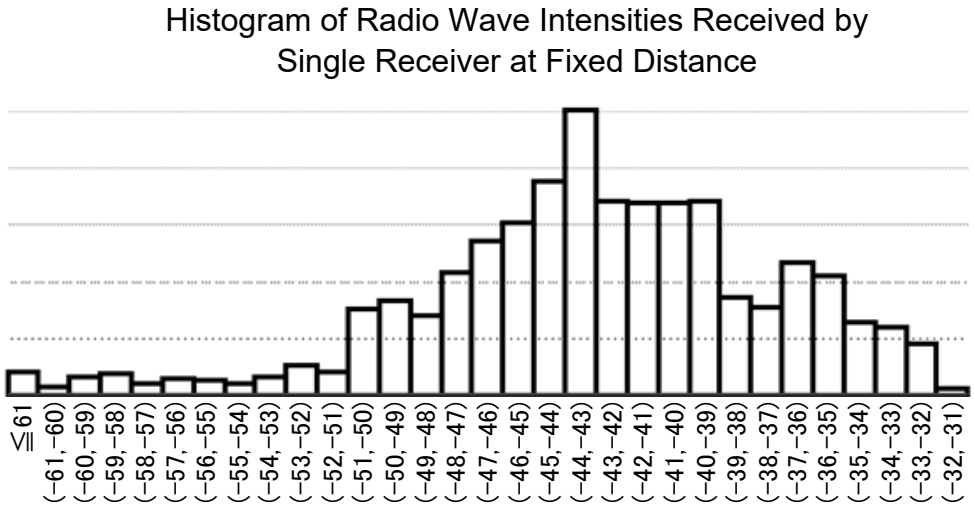

Histogram of Radio Wave Intensities Received by
Single Receiver at Fixed Distance
≦61
(−61,−60)
(−60,−59)
(−59,−58)
(−58,−57)
(−57,−56)
(−56,−55)
(−55,−54)
(−54,−53)
(−53,−52)
(−52,−51)
(−51,−50)
(−50,−49)
(−49,−48)
(−48,−47)
(−47,−46)
(−46,−45)
(−45,−44)
(−44,−43)
(−43,−42)
(−42,−41)
(−41,−40)
(−40,−39)
(−39,−38)
(−38,−37)
(−37,−36)
(−36,−35)
(−35,−34)
(−34,−33)
(−33,−32)
(−32,−31)

FIG. 10

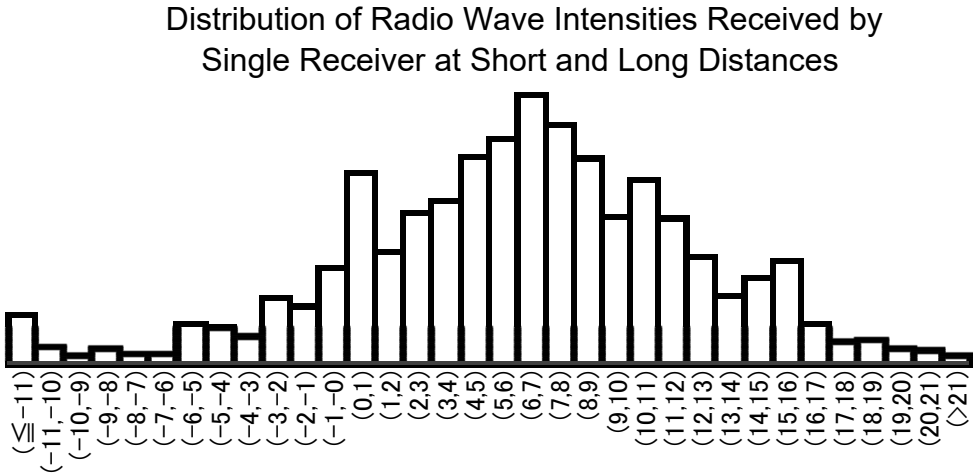

Distribution of Radio Wave Intensities Received by
Single Receiver at Short and Long Distances
(≦−11)
(−11,−10)
(−10,−9)
(−9,−8)
(−8,−7)
(−7,−6)
(−6,−5)
(−5,−4)
(−4,−3)
(−3,−2)
(−2,−1)
(−1,−0)
(0,1)
(1,2)
(2,3)
(3,4)
(4,5)
(5,6)
(6,7)
(7,8)
(8,9)
(9,10)
(10,11)
(11,12)
(12,13)
(13,14)
(14,15)
(15,16)
(16,17)
(17,18)
(18,19)
(19,20)
(20,21)
(>21)

FIG. 11

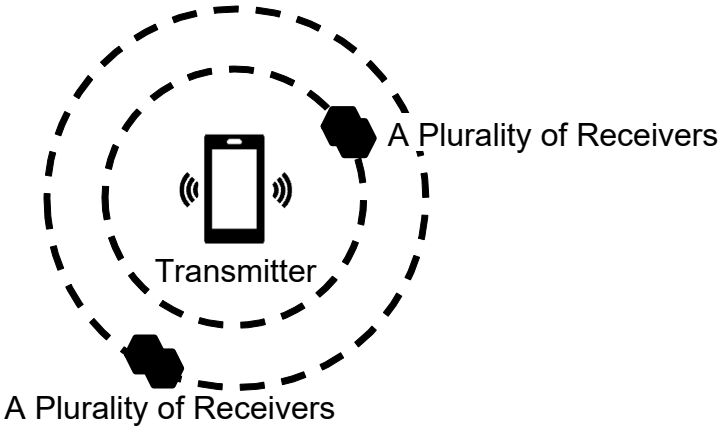

A Plurality of Receivers
Transmitter
A Plurality of Receivers

FIG. 12

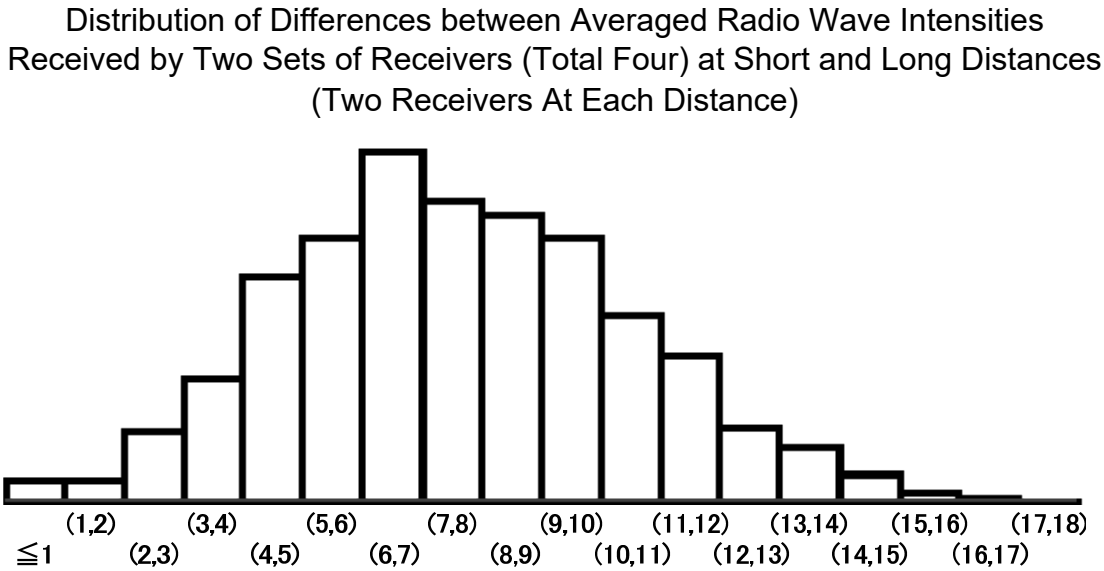

Distribution of Differences between Averaged Radio Wave Intensities
Received by Two Sets of Receivers (Total Four) at Short and Long Distances
(Two Receivers At Each Distance)
≦1
(1,2)
(2,3)
(3,4)
(4,5)
(5,6)
(6,7)
(7,8)
(8,9)
(9,10)
(10,11)
(11,12)
(12,13)
(13,14)
(14,15)
(15,16)
(16,17)
(17,18)

FIG. 13

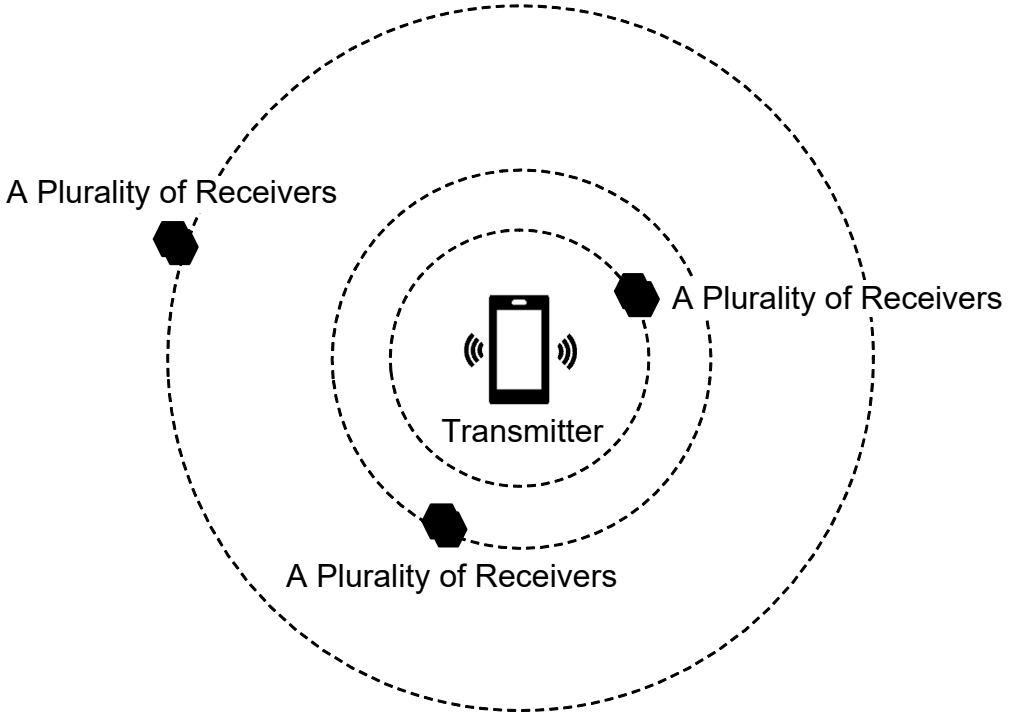

A Plurality of Receivers
A Plurality of Receivers
Transmitter
A Plurality of Receivers

FIG. 14

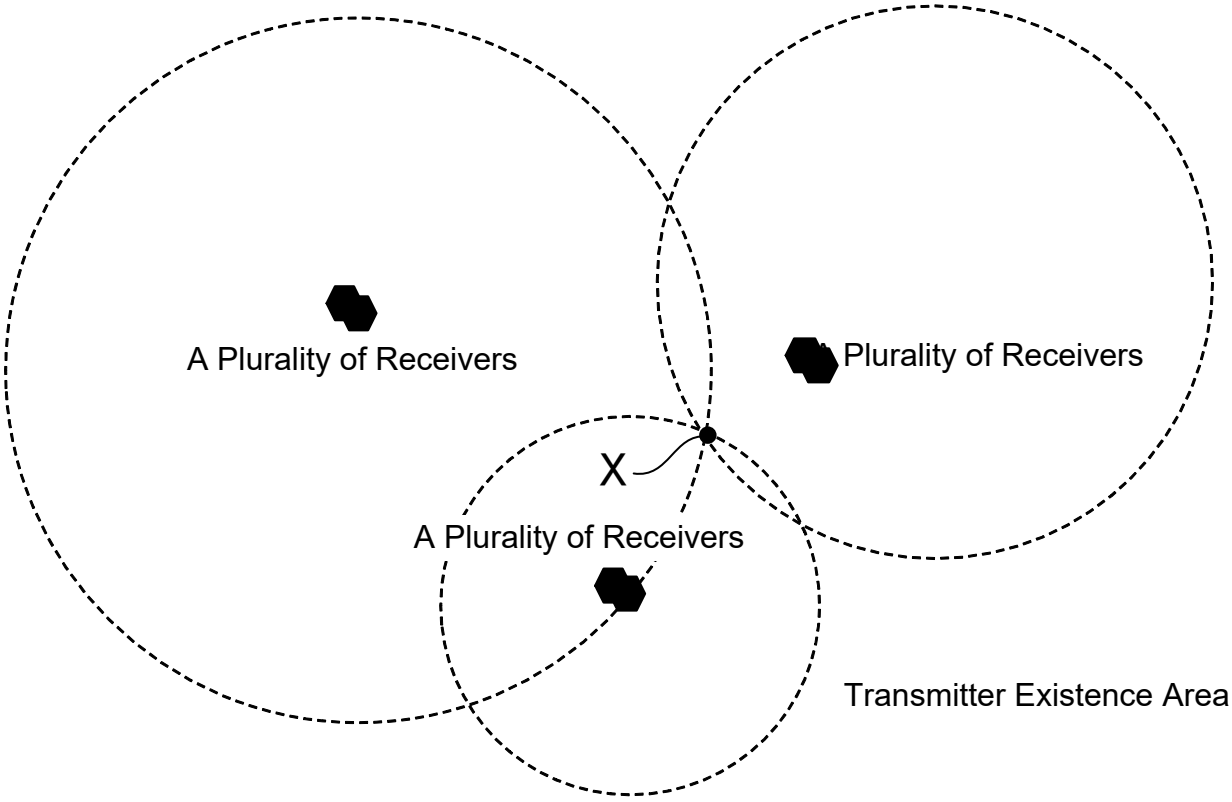

A Plurality of Receivers
Plurality of Receivers
X
A Plurality of Receivers
Transmitter Existence Area

FIG. 15

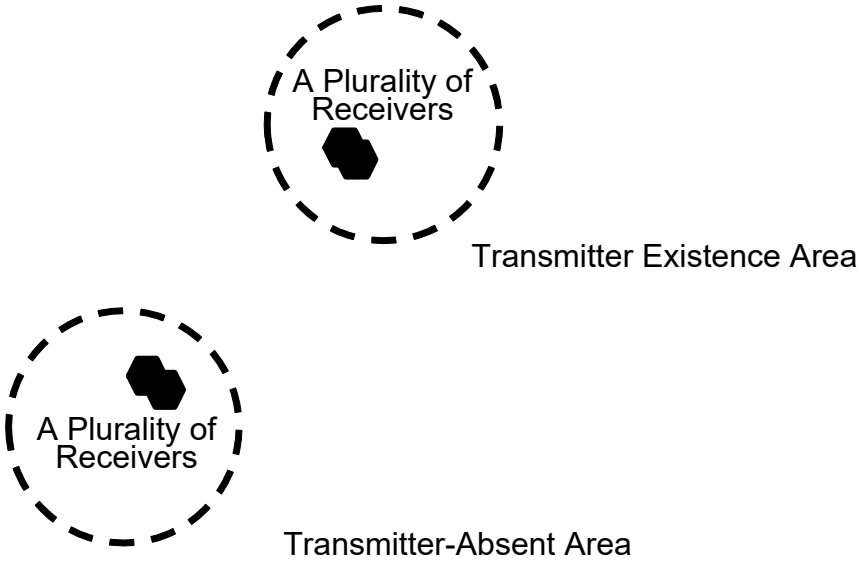

A Plurality of Receivers
Transmitter Existence Area
A Plurality of Receivers
Transmitter-Absent Area

FIG. 16

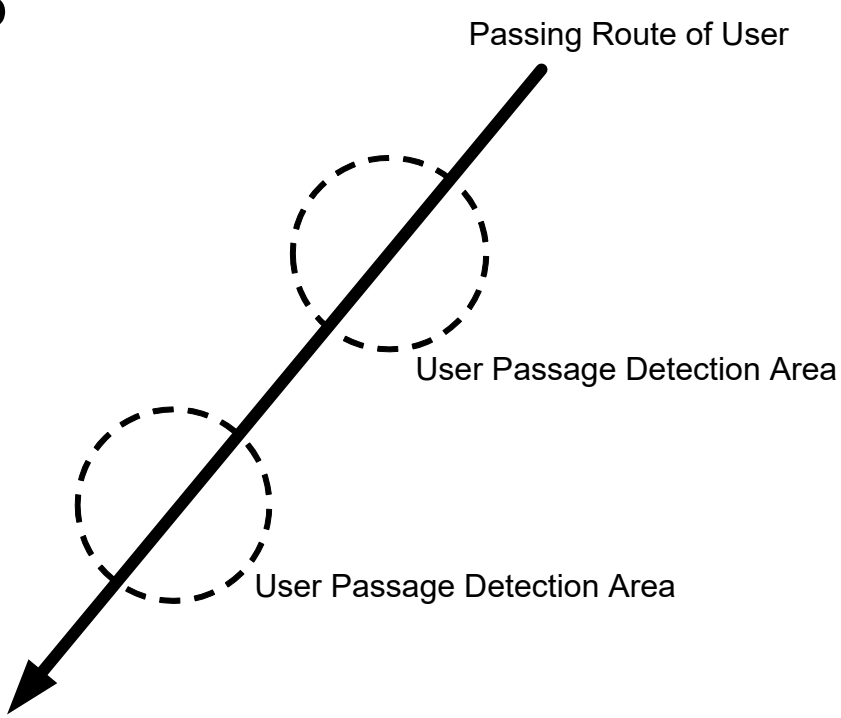

Passing Route of User
User Passage Detection Area
User Passage Detection Area

FIG. 17

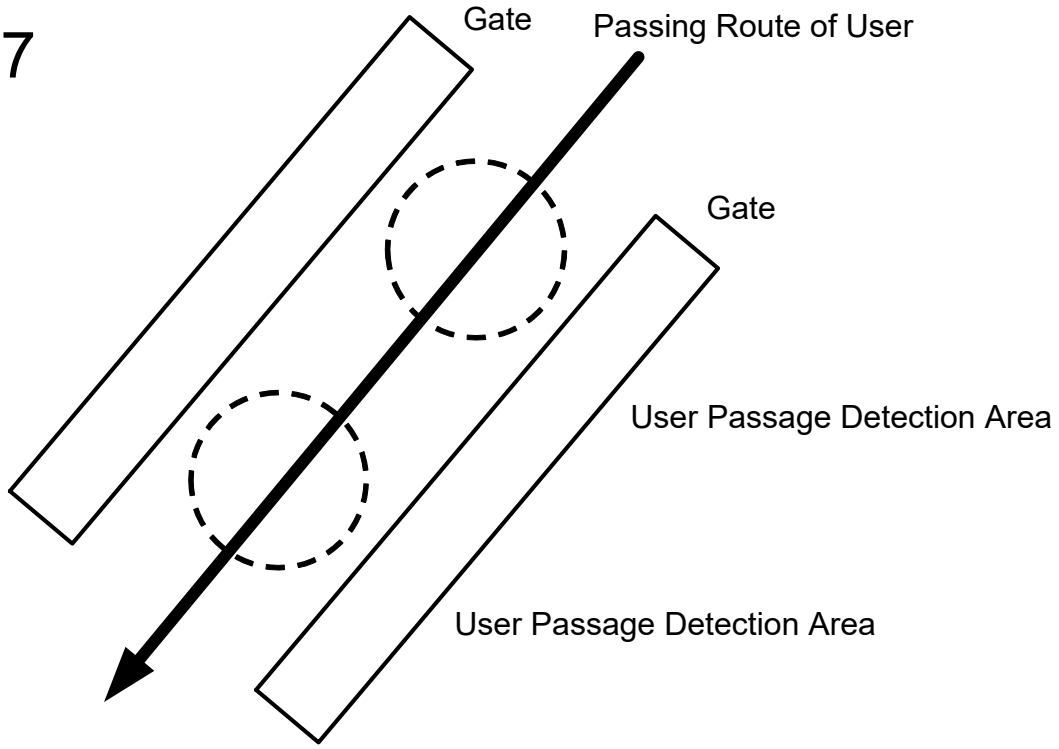

Gate
Passing Route of User
Gate
User Passage Detection Area
User Passage Detection Area

FIG. 18

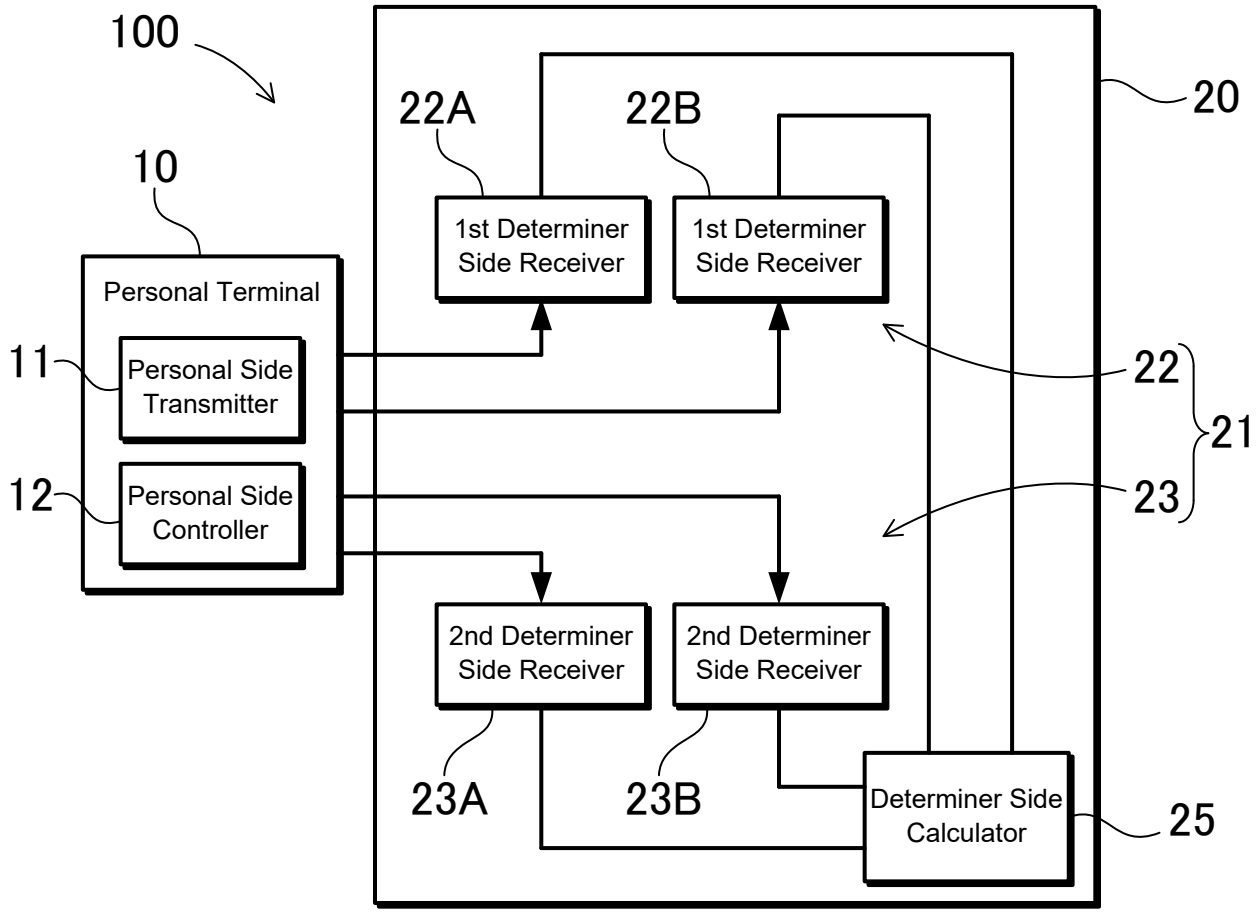

100
10
Personal Terminal
11
Personal Side Transmitter
12
Personal Side Controller
22A
22B
1st Determiner Side Receiver
1st Determiner Side Receiver
20
22
21
23
2nd Determiner Side Receiver
2nd Determiner Side Receiver
23A
23B
Determiner Side Calculator
25

FIG. 19

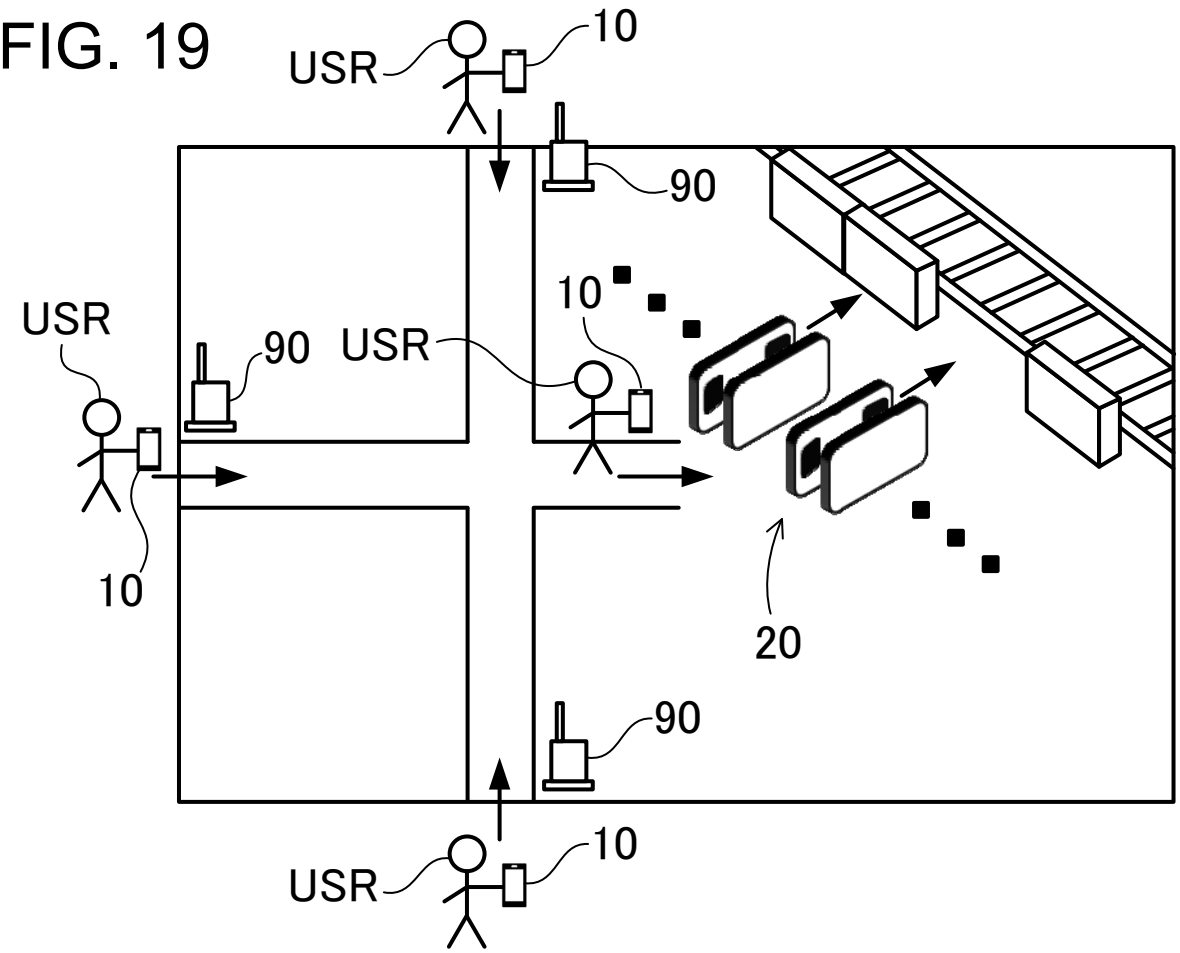

USR
10
90
USR
90
USR
10
10
20
90
USR
10

FIG. 20

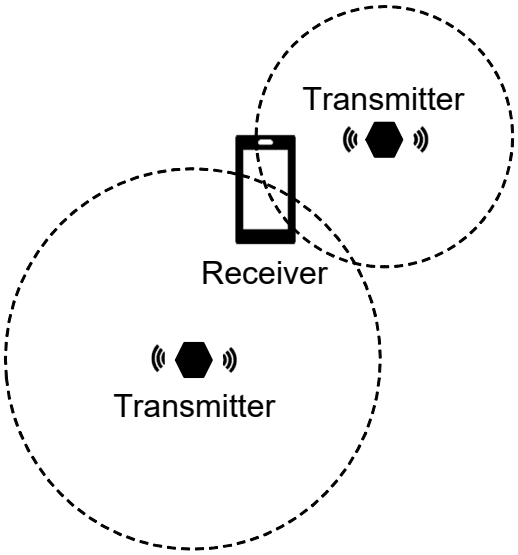

Transmitter
Receiver
Transmitter

FIG. 21

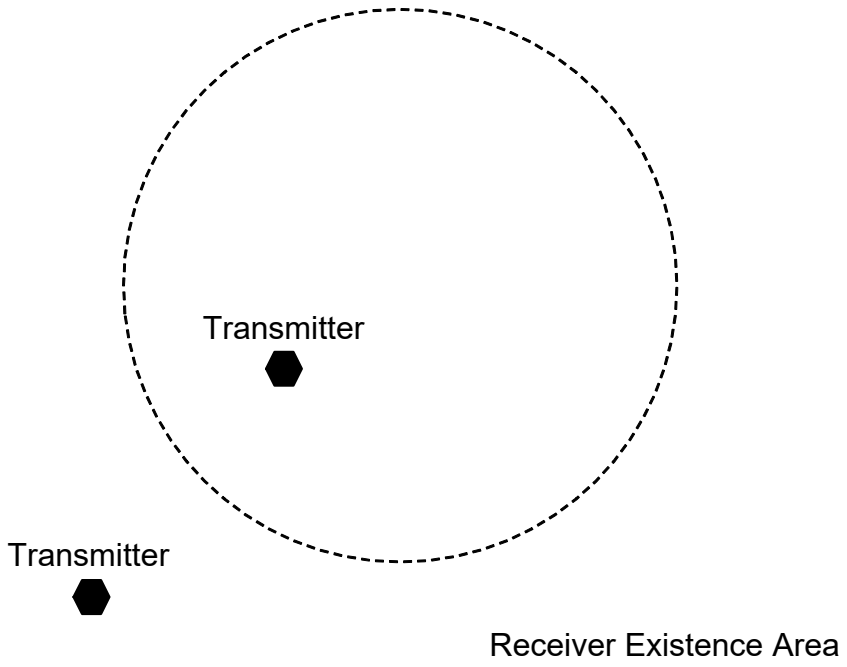

Transmitter
Transmitter
Receiver Existence Area

FIG. 22

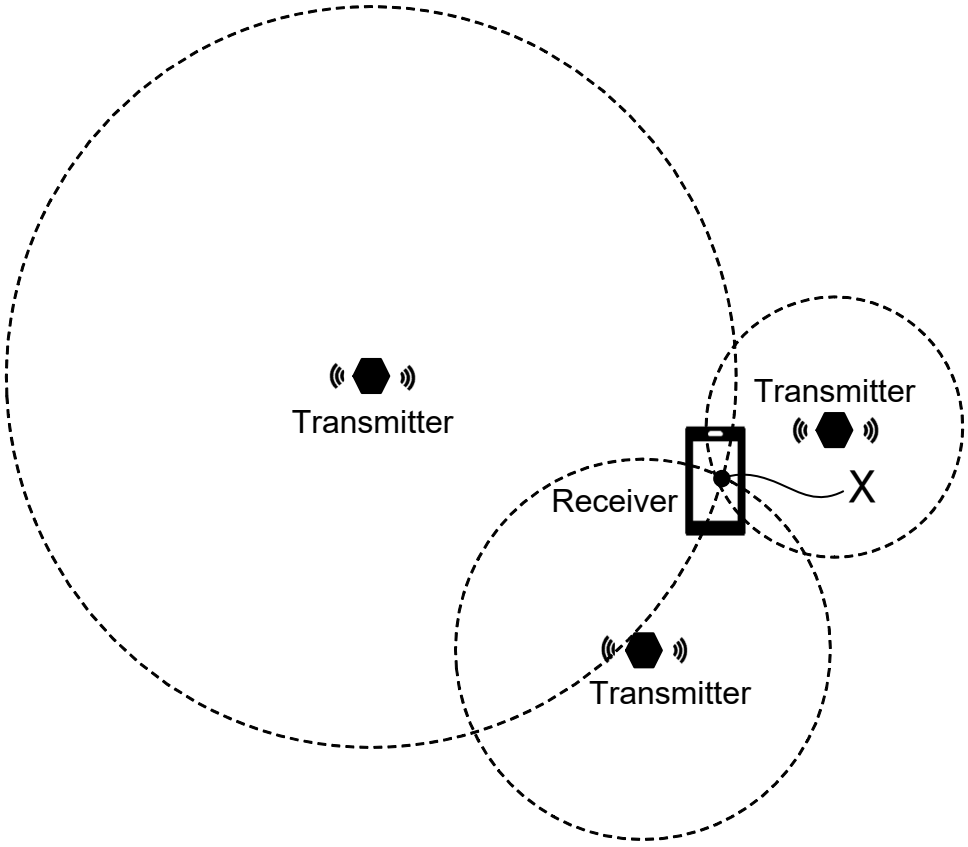

Transmitter
Transmitter
Receiver
X
Transmitter

FIG. 23

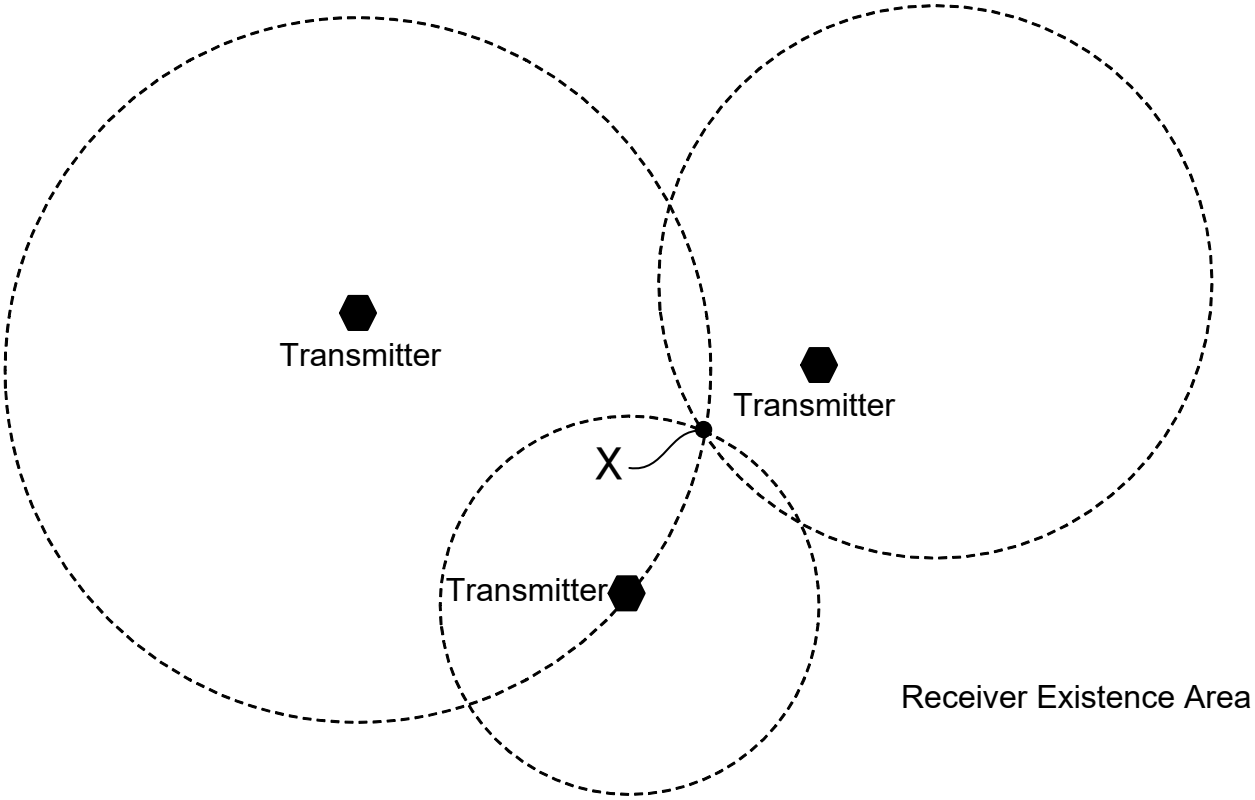

Transmitter
Transmitter
X
Transmitter
Receiver Existence Area

FIG. 24

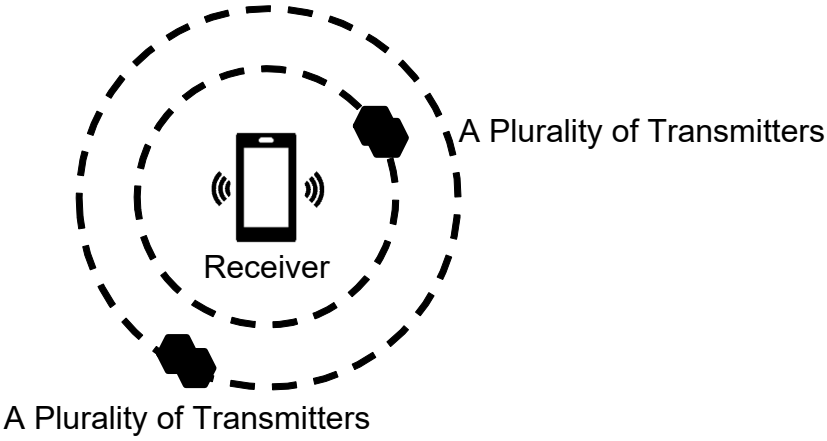

A Plurality of Transmitters
Receiver
A Plurality of Transmitters

FIG. 25

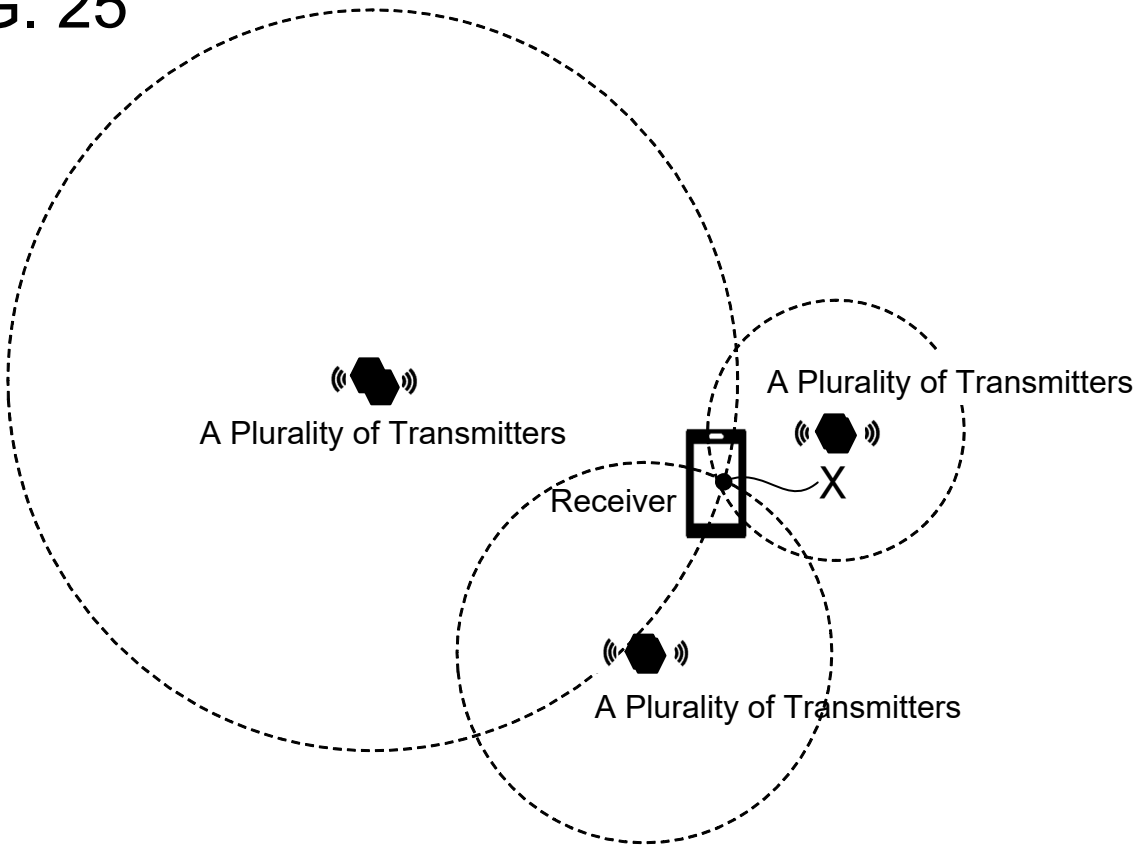

A Plurality of Transmitters
A Plurality of Transmitters
Receiver
X
A Plurality of Transmitters

FIG. 26

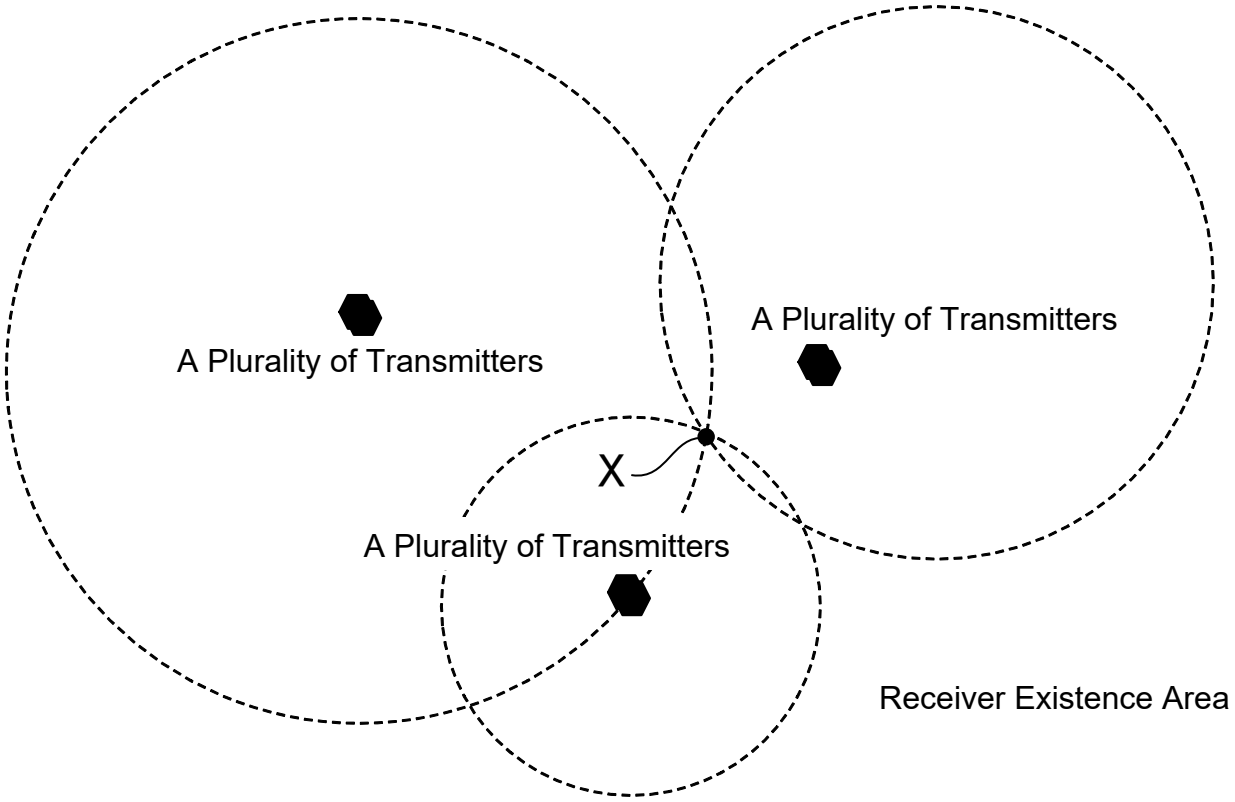

A Plurality of Transmitters
A Plurality of Transmitters
X
A Plurality of Transmitters
Receiver Existence Area

FIG. 27

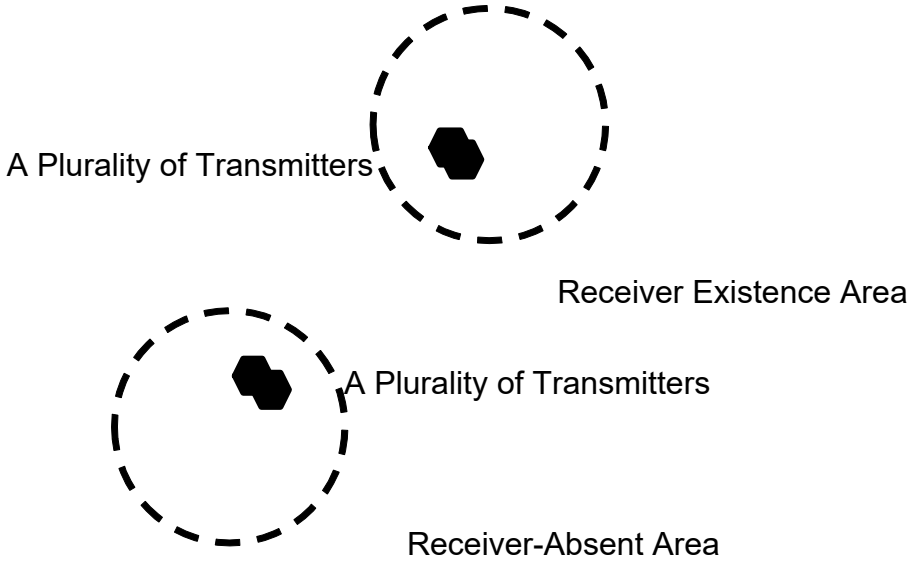

A Plurality of Transmitters
Receiver Existence Area
A Plurality of Transmitters
Receiver-Absent Area

FIG. 28

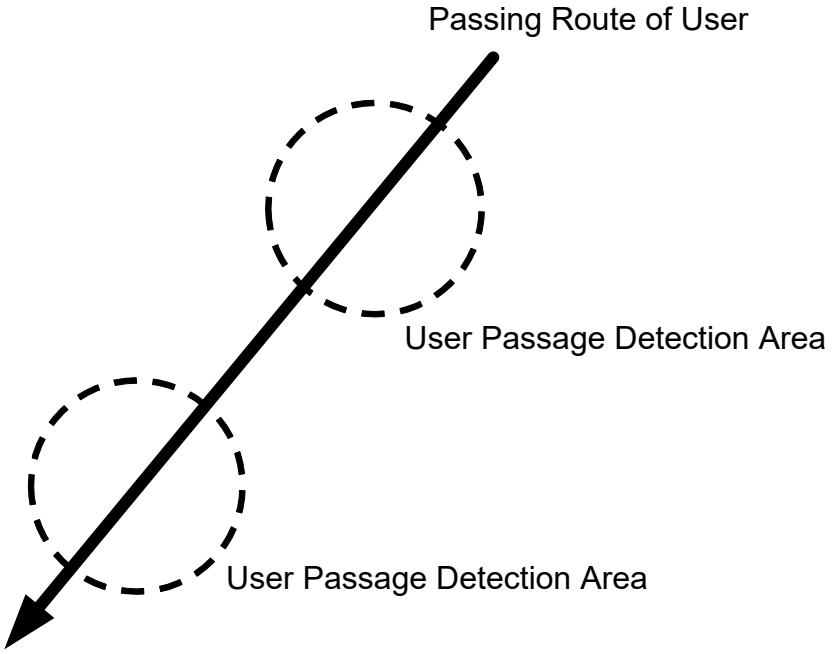
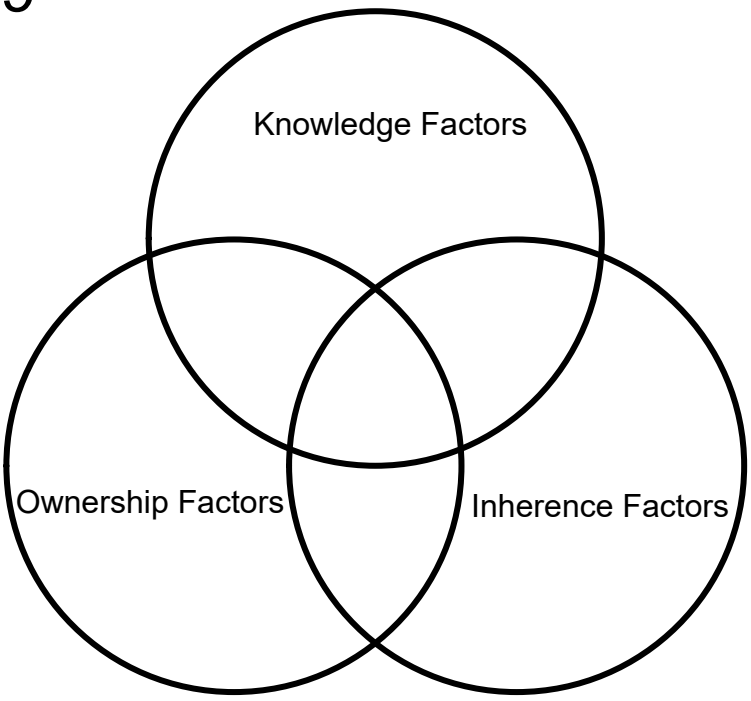

Passing Route of User
User Passage Detection Area
User Passage Detection Area

FIG. 29



Three Elements of Authentication

FIG. 30

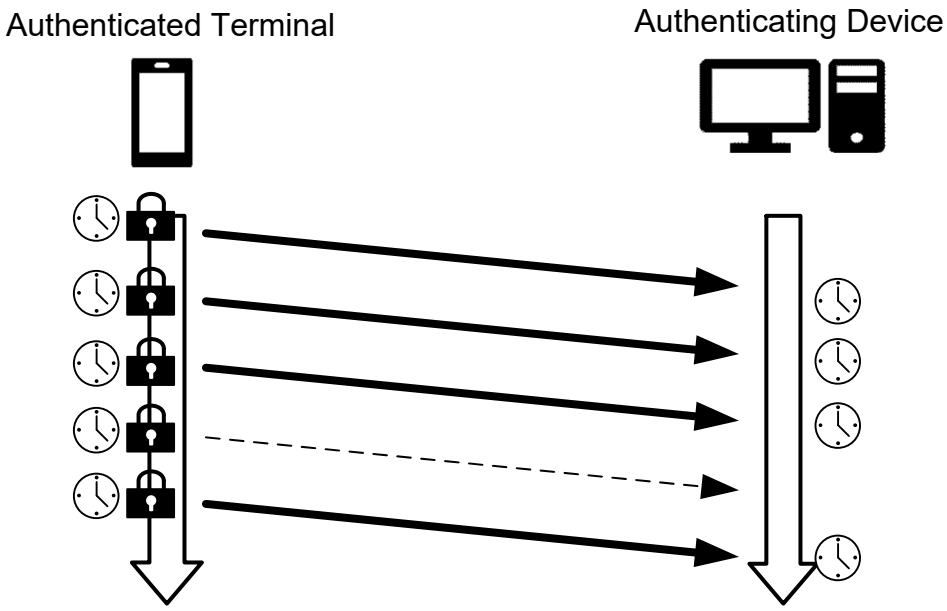


FIG. 31

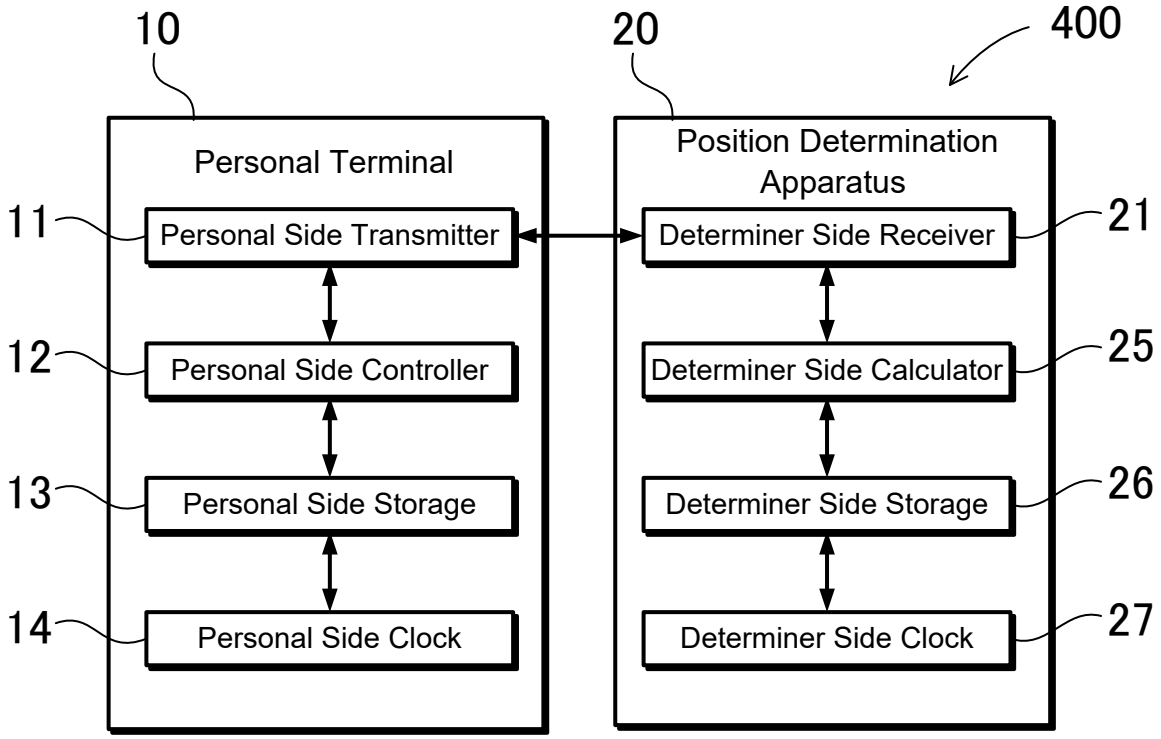

10
20
400
Personal Terminal
Position Determination Apparatus
11
Personal Side Transmitter
Determiner Side Receiver
21
12
Personal Side Controller
Determiner Side Calculator
25
13
Personal Side Storage
Determiner Side Storage
26
14
Personal Side Clock
Determiner Side Clock
27

FIG. 32

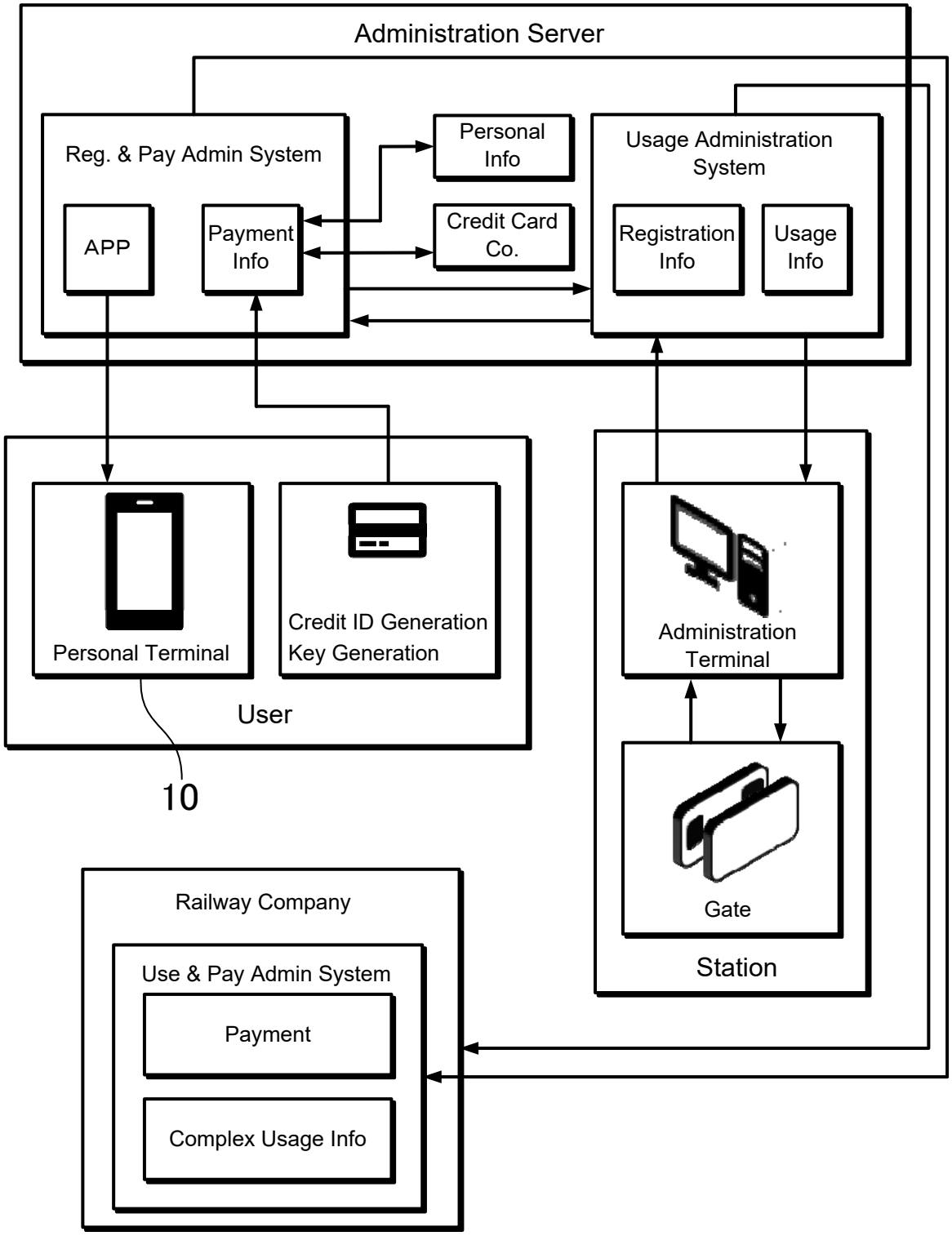

Administration Server
Reg. & Pay Admin System
APP
Payment Info
Personal Info
Credit Card Co.
Usage Administration System
Registration Info
Usage Info
Personal Terminal
Credit ID Generation
Key Generation
User
10
Administration Terminal
Gate
Station
Railway Company
Use & Pay Admin System
Payment
Complex Usage Info

FIG. 33

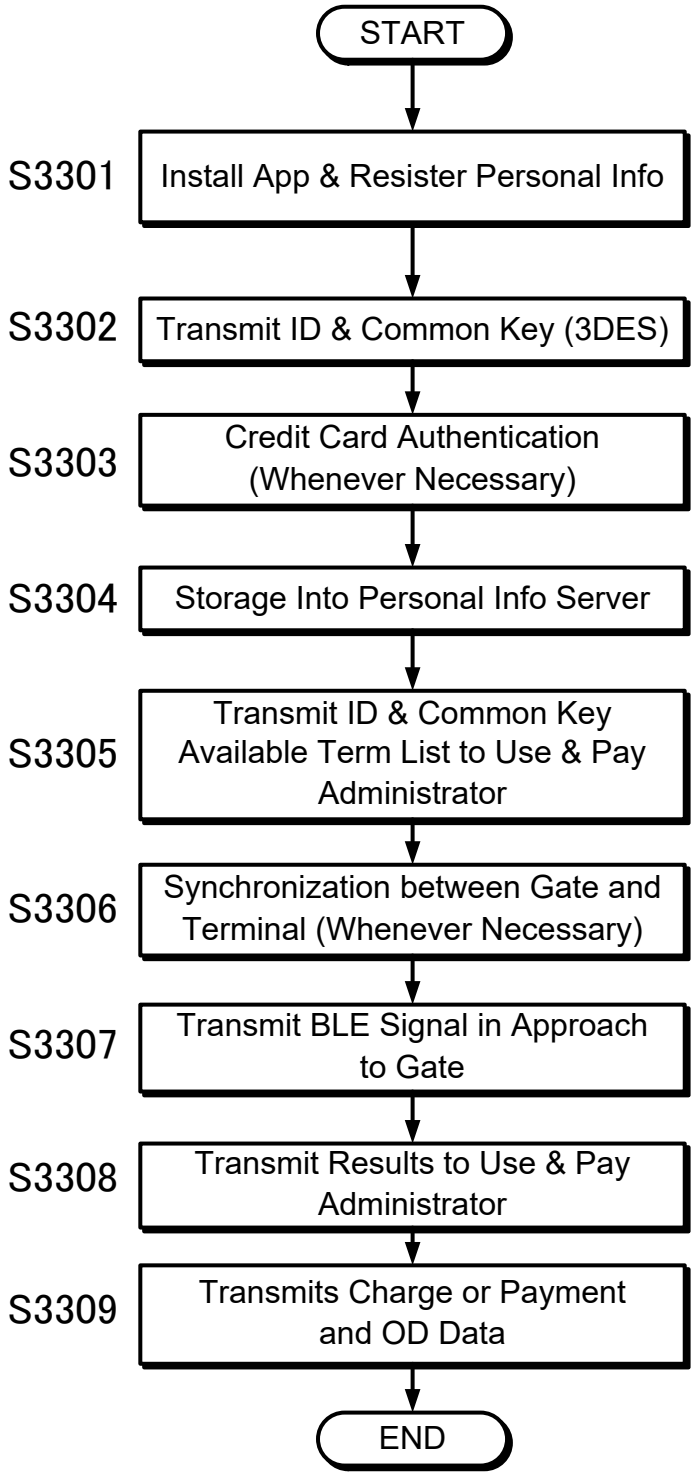

START
S3301
Install App & Resister Personal Info
S3302
Transmit ID & Common Key (3DES)
S3303
Credit Card Authentication (Whenever Necessary)
S3304
Storage Into Personal Info Server
S3305
Transmit ID & Common Key Available Term List to Use & Pay Administrator
S3306
Synchronization between Gate and Terminal (Whenever Necessary)
S3307
Transmit BLE Signal in Approach to Gate
S3308
Transmit Results to Use & Pay Administrator
S3309
Transmits Charge or Payment and OD Data
END

FIG. 34

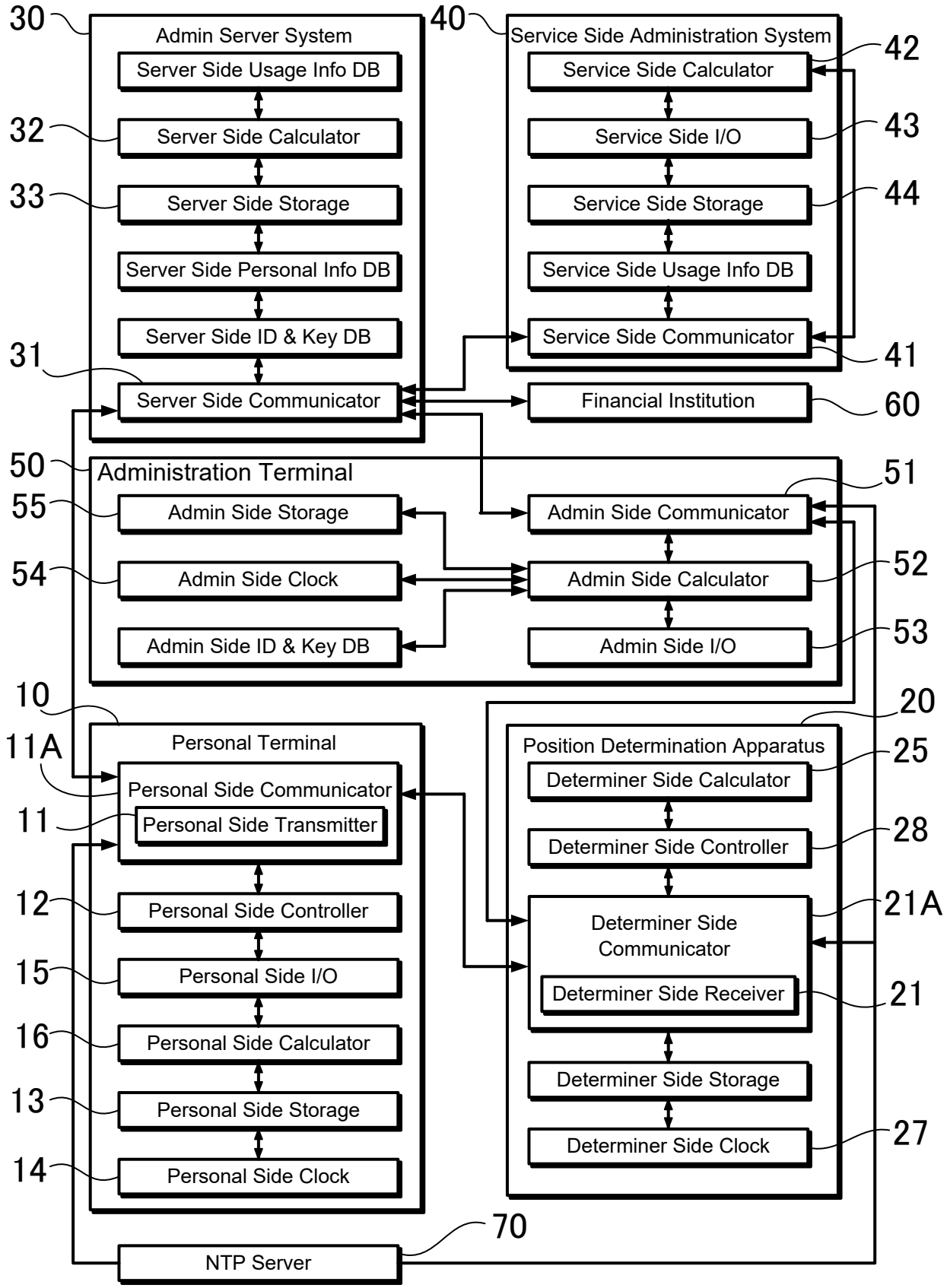

30
Admin Server System
Server Side Usage Info DB
32
Server Side Calculator
33
Server Side Storage
Server Side Personal Info DB
Server Side ID & Key DB
31
Server Side Communicator
40
Service Side Administration System
Service Side Calculator
42
Service Side I/O
43
Service Side Storage
44
Service Side Usage Info DB
Service Side Communicator
41
Financial Institution
60
50
Administration Terminal
51
55
Admin Side Storage
Admin Side Communicator
54
Admin Side Clock
Admin Side Calculator
52
Admin Side ID & Key DB
Admin Side I/O
53
10
20
11A
Personal Terminal
Position Determination Apparatus
25
Personal Side Communicator
Determiner Side Calculator
11
Personal Side Transmitter
Determiner Side Controller
28
12
Personal Side Controller
21A
Determiner Side Communicator
15
Personal Side I/O
Determiner Side Receiver
21
16
Personal Side Calculator
Determiner Side Storage
13
Personal Side Storage
27
Determiner Side Clock
14
Personal Side Clock
70
NTP Server

FIG. 35A

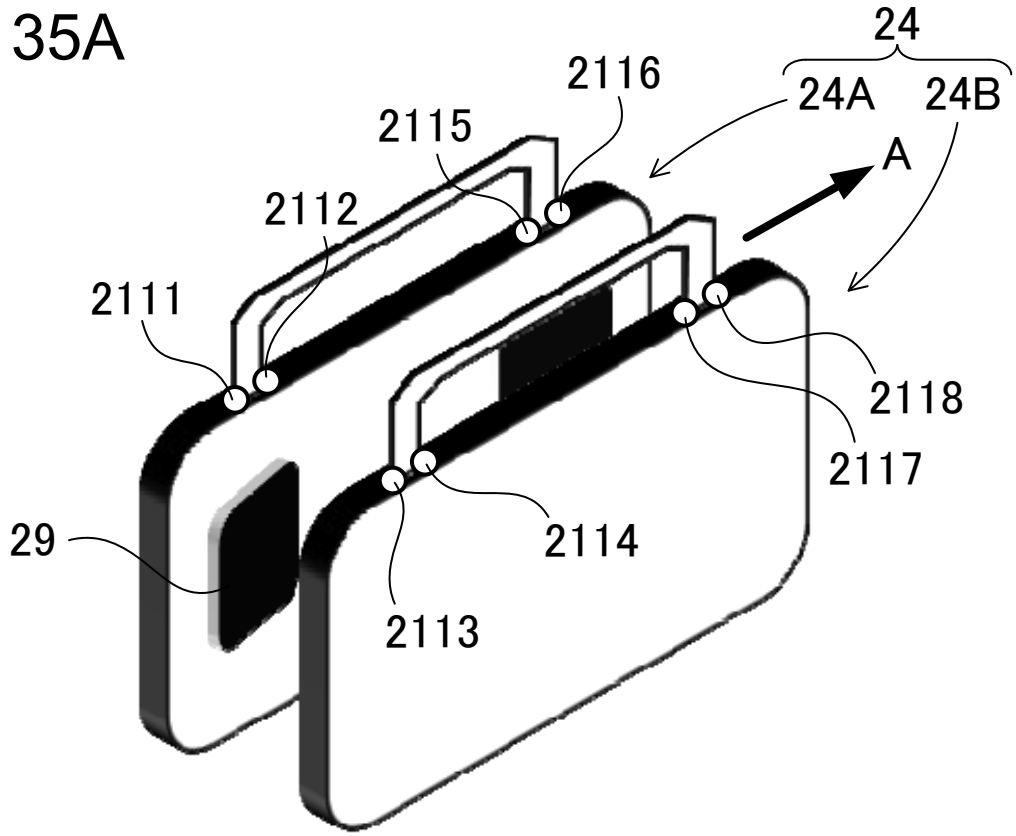


FIG. 35B

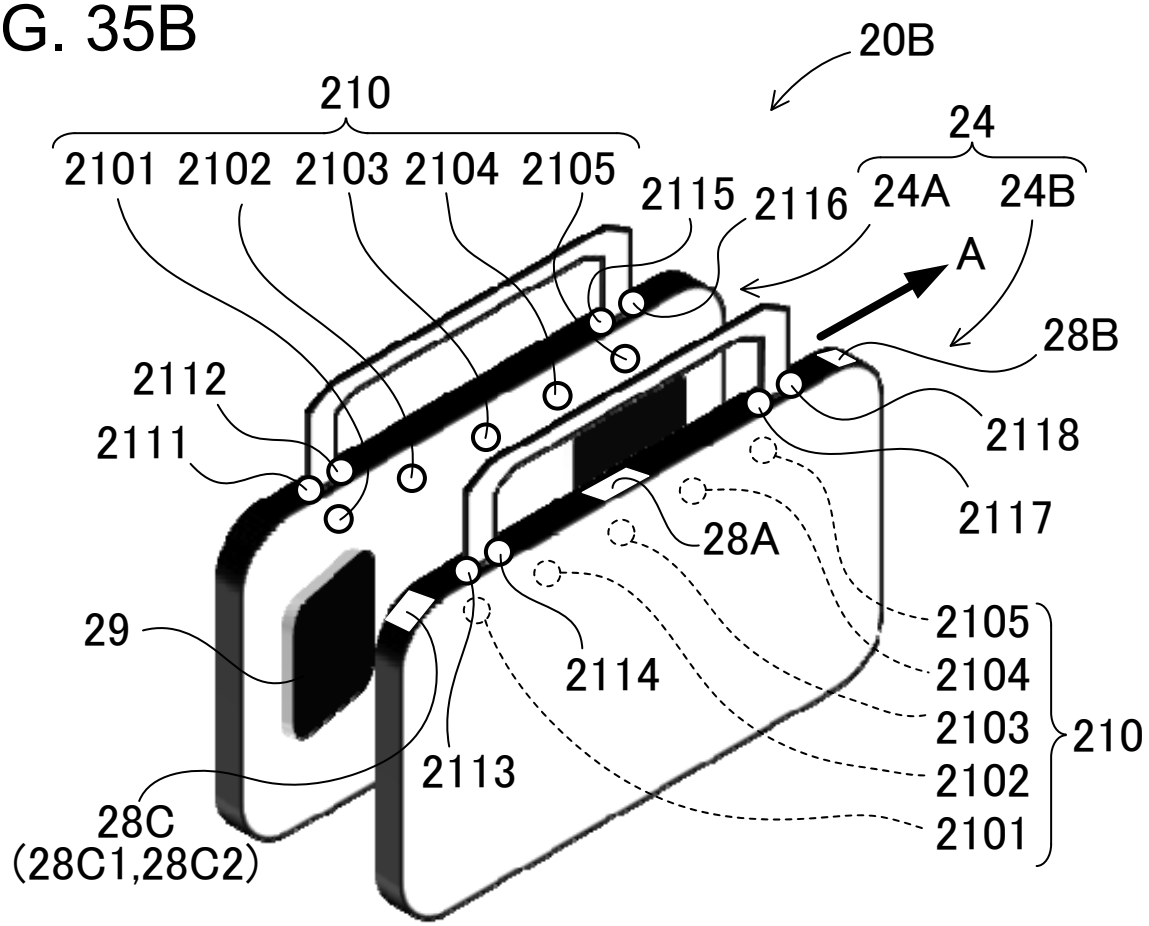


FIG. 36A

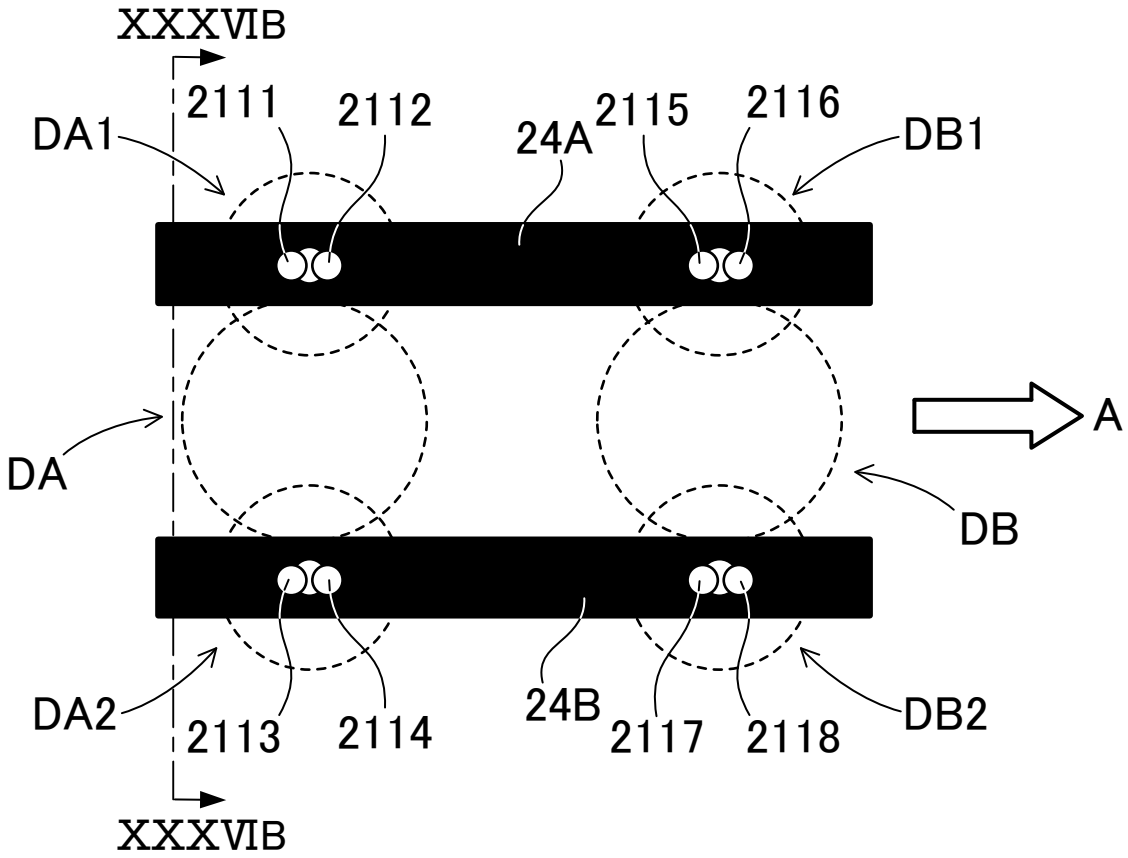


FIG. 36B

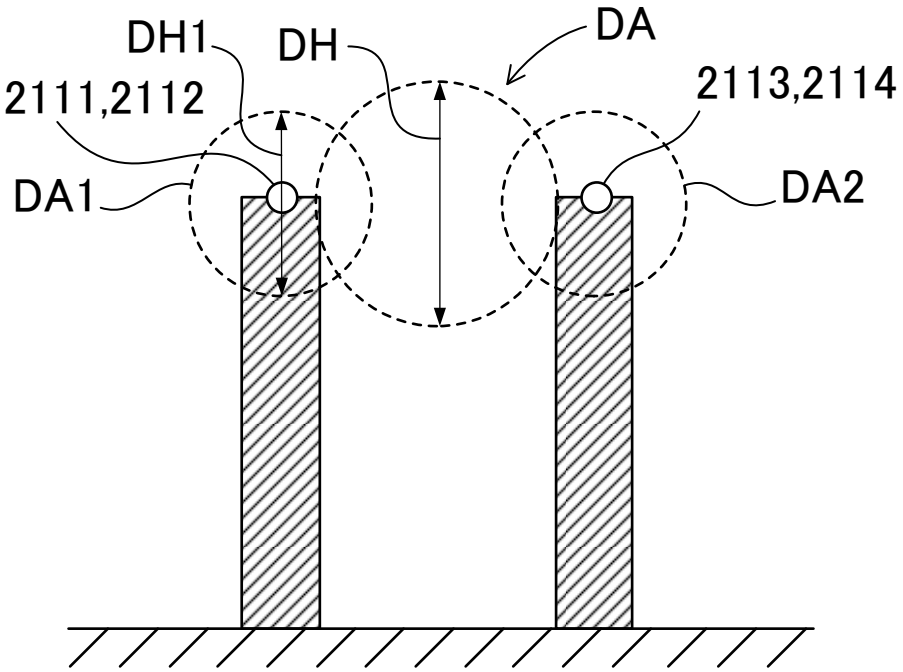


FIG. 37

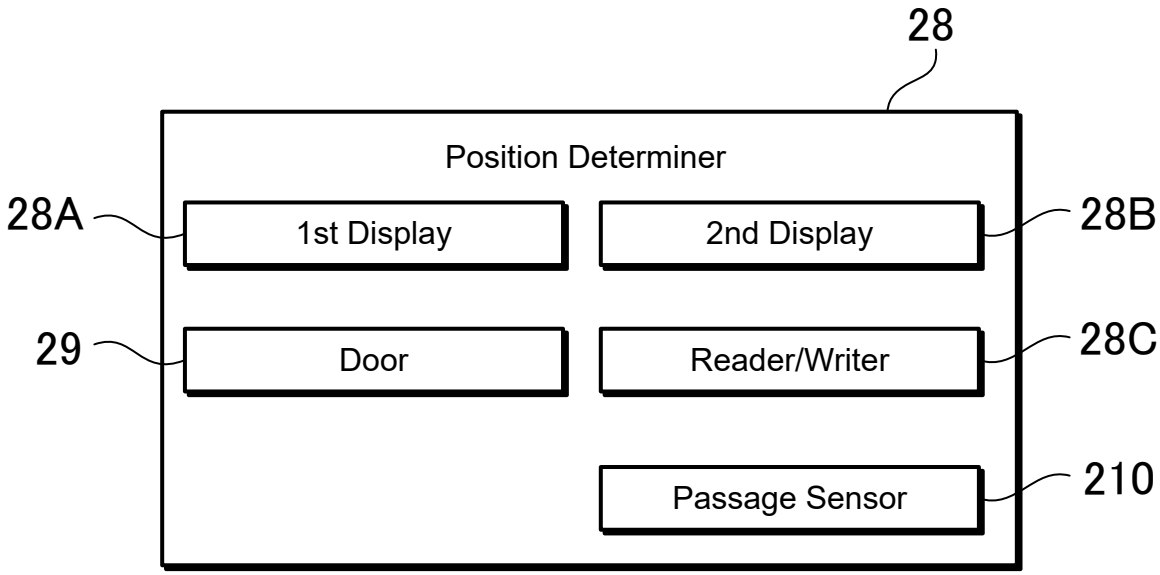

28
Position Determiner
28A
1st Display
2nd Display
28B
29
Door
Reader/Writer
28C
Passage Sensor
210

FIG. 38

Advance Phase

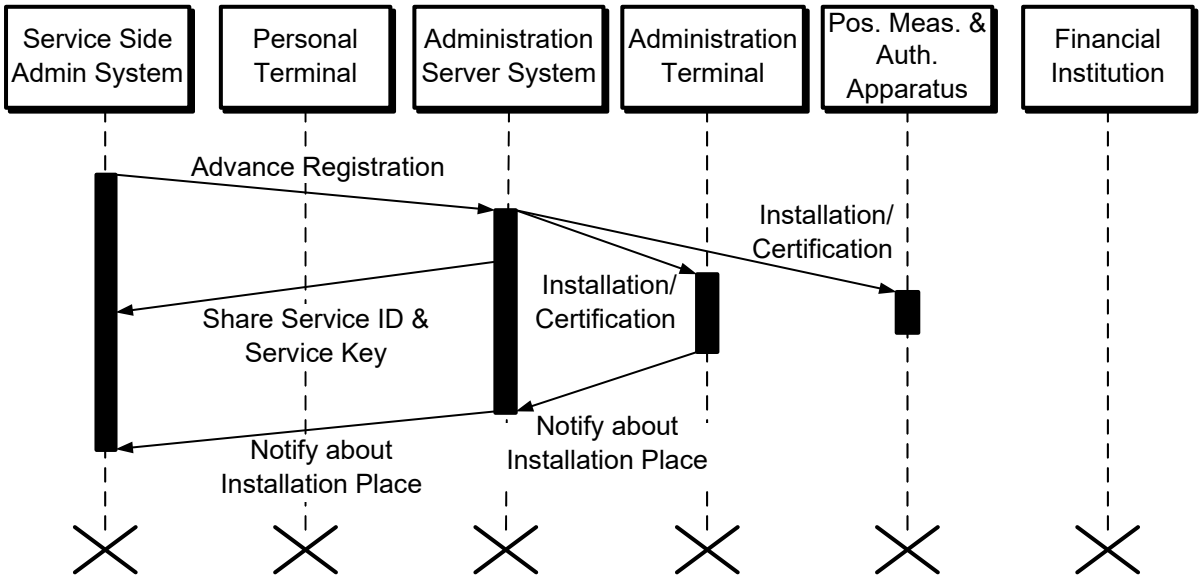


FIG. 39

Advance Phase

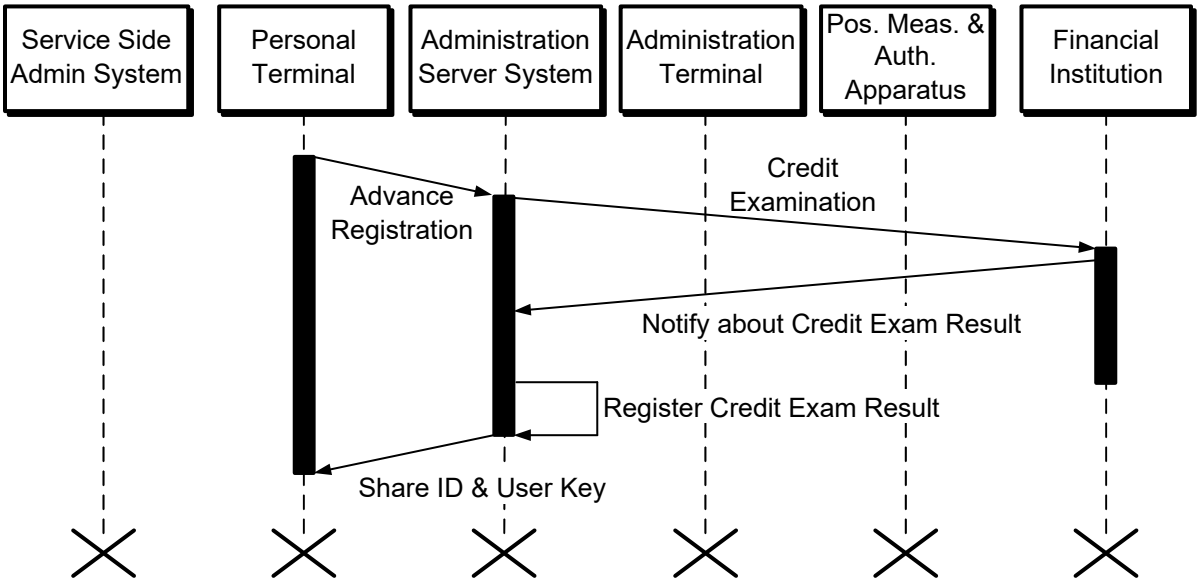


FIG. 40

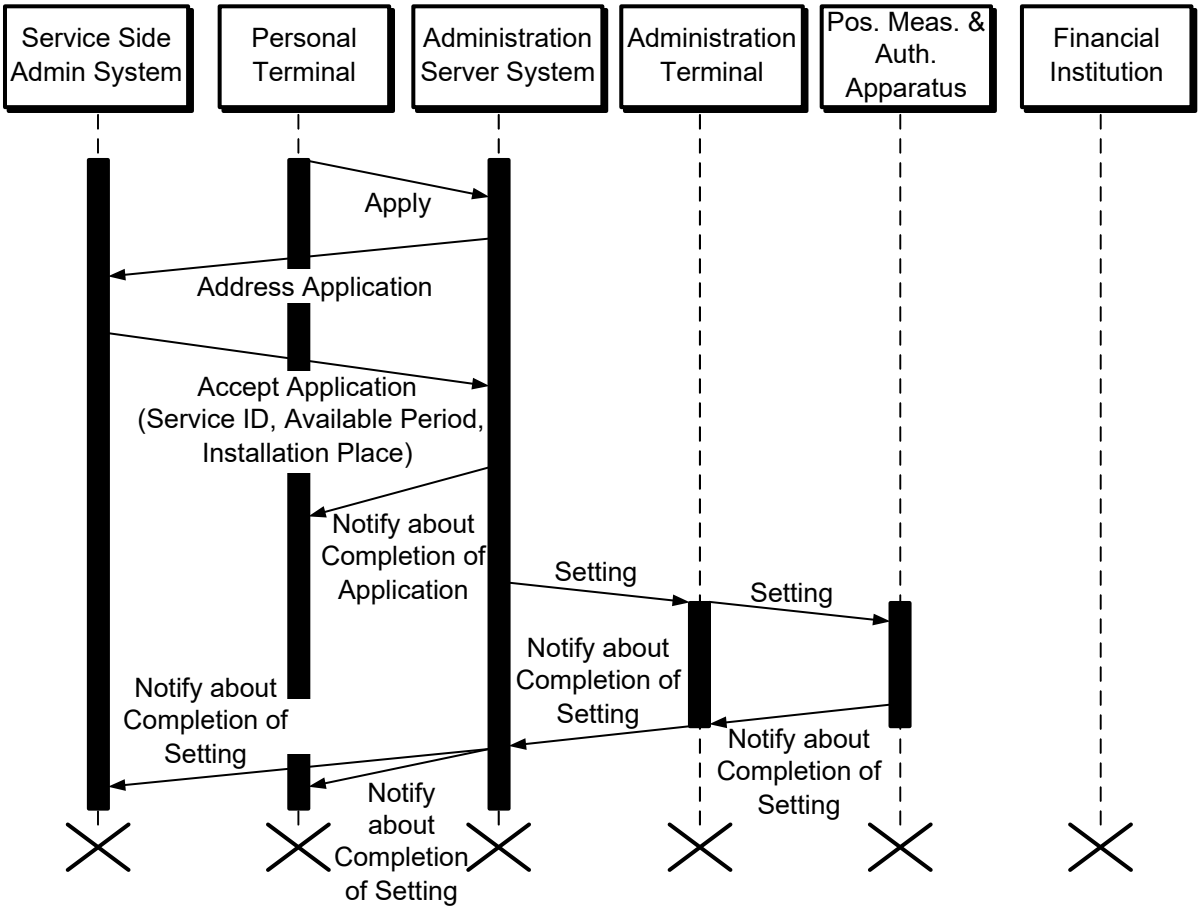

Service Side Admin System
Personal Terminal
Administration Server System
Administration Terminal
Pos. Meas. & Auth. Apparatus
Financial Institution
Apply
Address Application
Accept Application (Service ID, Available Period, Installation Place)
Notify about Completion of Application
Setting
Setting
Notify about Completion of Setting
Notify about Completion of Setting
Notify about Completion of Setting
Notify about Completion of Setting

FIG. 41

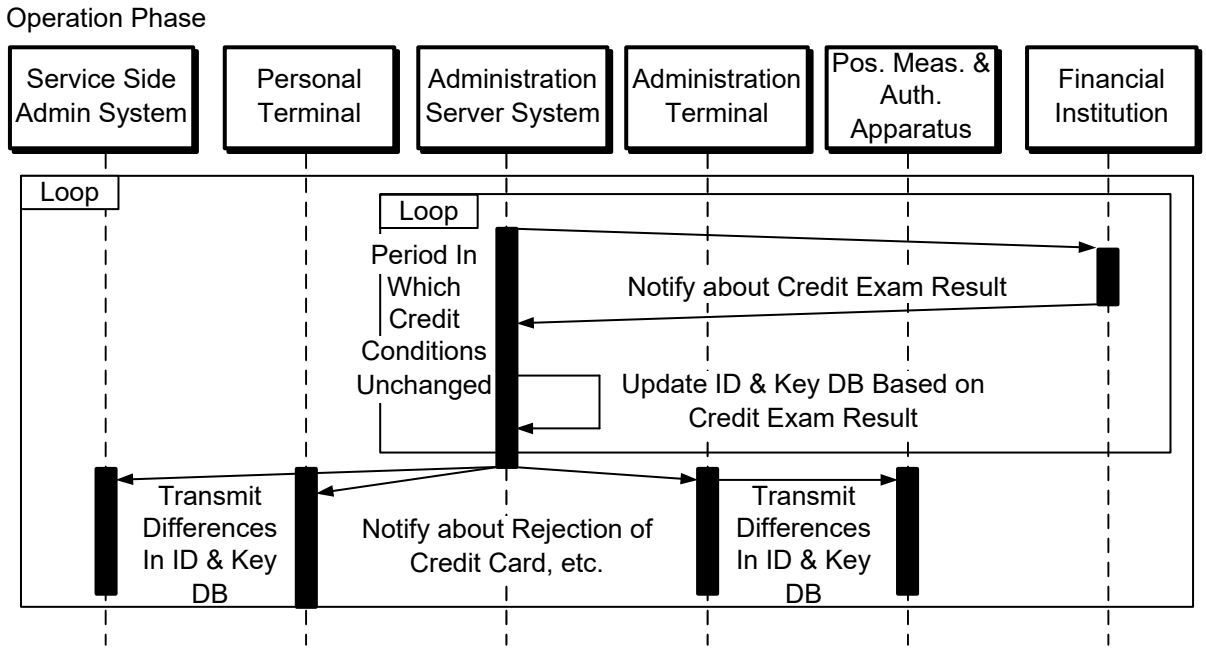

Operation Phase
Service Side Admin System
Personal Terminal
Administration Server System
Administration Terminal
Pos. Meas. & Auth. Apparatus
Financial Institution
Loop
Loop
Period In Which Credit Conditions Unchanged
Notify about Credit Exam Result
Update ID & Key DB Based on Credit Exam Result
Transmit Differences In ID & Key DB
Notify about Rejection of Credit Card, etc.
Transmit Differences In ID & Key DB

FIG. 42

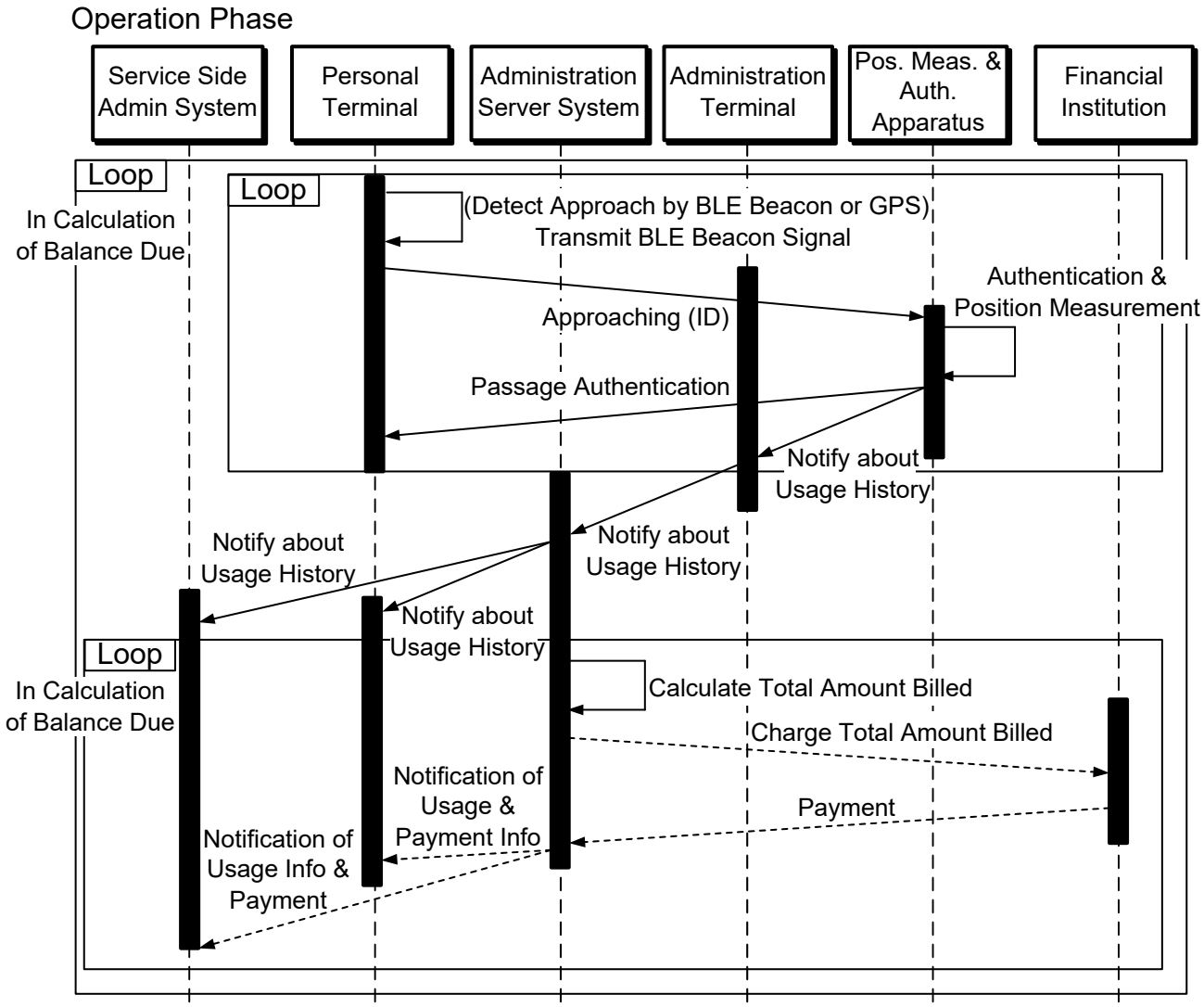

Operation Phase
Service Side Admin System
Personal Terminal
Administration Server System
Administration Terminal
Pos. Meas. & Auth. Apparatus
Financial Institution
Loop
In Calculation of Balance Due
Loop
(Detect Approach by BLE Beacon or GPS)
Transmit BLE Beacon Signal
Authentication & Position Measurement
Approaching (ID)
Passage Authentication
Notify about Usage History
Notify about Usage History
Notify about Usage History
Notify about Usage History
Loop
In Calculation of Balance Due
Calculate Total Amount Billed
Charge Total Amount Billed
Notification of Usage & Payment Info
Payment
Notification of Usage Info & Payment

FIG. 43

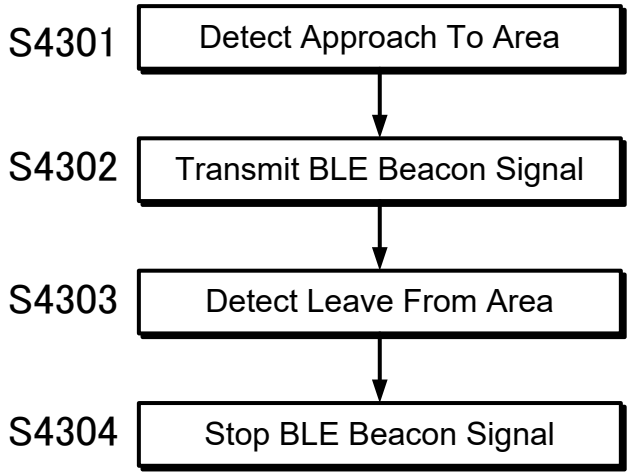

S4301
Detect Approach To Area
S4302
Transmit BLE Beacon Signal
S4303
Detect Leave From Area
S4304
Stop BLE Beacon Signal

FIG. 44

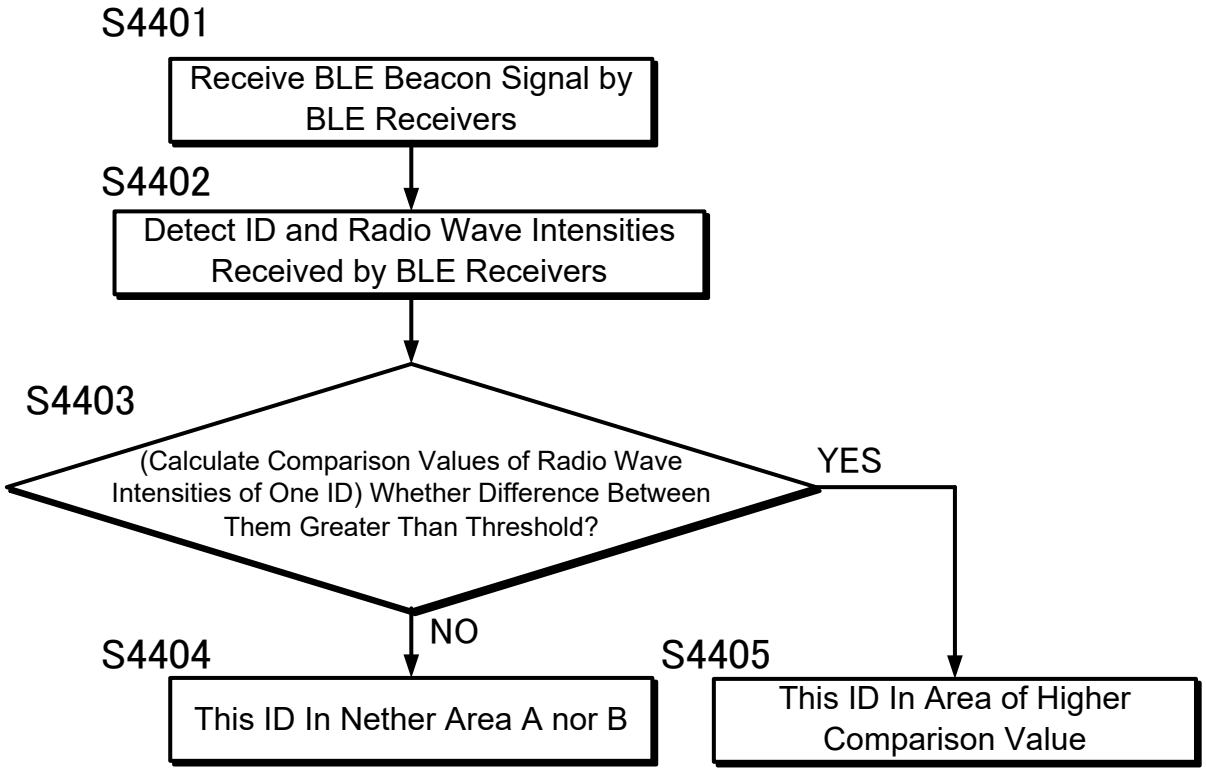

S4401
Receive BLE Beacon Signal by BLE Receivers
S4402
Detect ID and Radio Wave Intensities Received by BLE Receivers
S4403
(Calculate Comparison Values of Radio Wave Intensities of One ID) Whether Difference Between Them Greater Than Threshold?
YES
NO
S4404
This ID In Nether Area A nor B
S4405
This ID In Area of Higher Comparison Value

FIG. 45

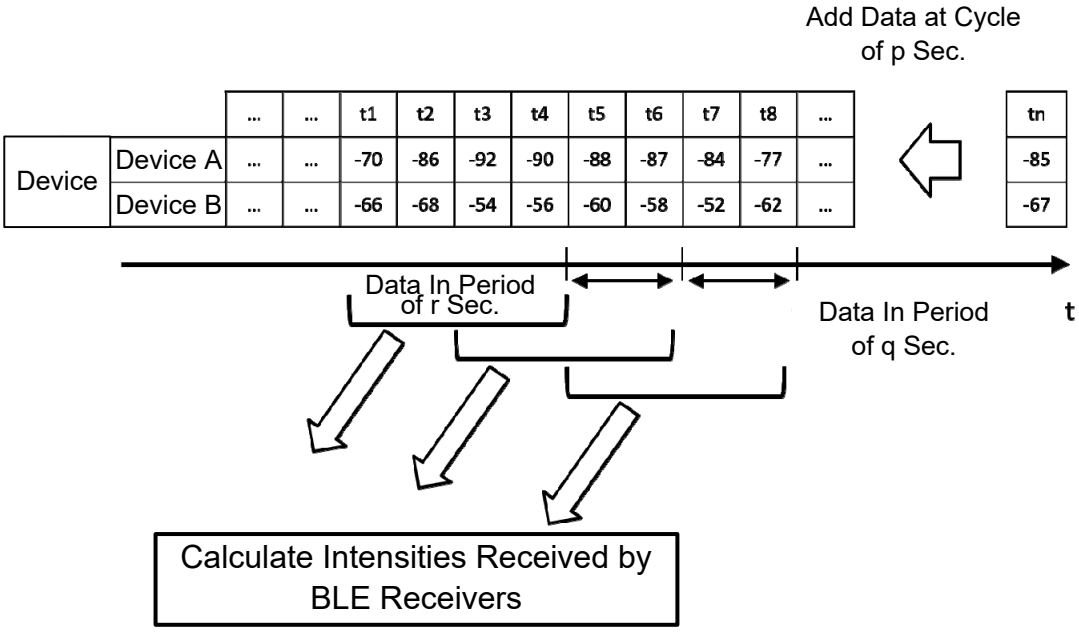

Add Data at Cycle of p Sec.
Device
Device A
Device B
... ... t1 t2 t3 t4 t5 t6 t7 t8 ...
... ... -70 -86 -92 -90 -88 -87 -84 -77 ...
... ... -66 -68 -54 -56 -60 -58 -52 -62 ...
tn
-85
-67
Data In Period of r Sec.
Data In Period of q Sec.
t
Calculate Intensities Received by BLE Receivers

FIG. 46

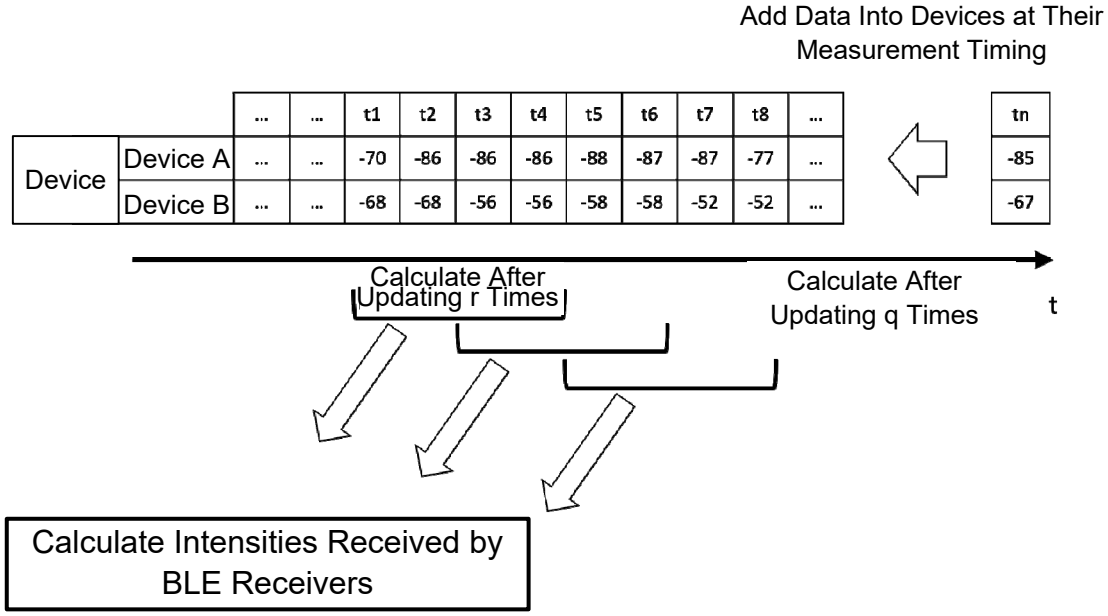

Add Data Into Devices at Their Measurement Timing
Device
Device A
Device B
... ... t1 t2 t3 t4 t5 t6 t7 t8 ...
... ... -70 -86 -86 -86 -88 -87 -87 -77 ...
... ... -68 -68 -56 -56 -58 -58 -52 -52 ...
tn
-85
-67
Calculate After Updating r Times
Calculate After Updating q Times
t
Calculate Intensities Received by BLE Receivers

FIG. 47

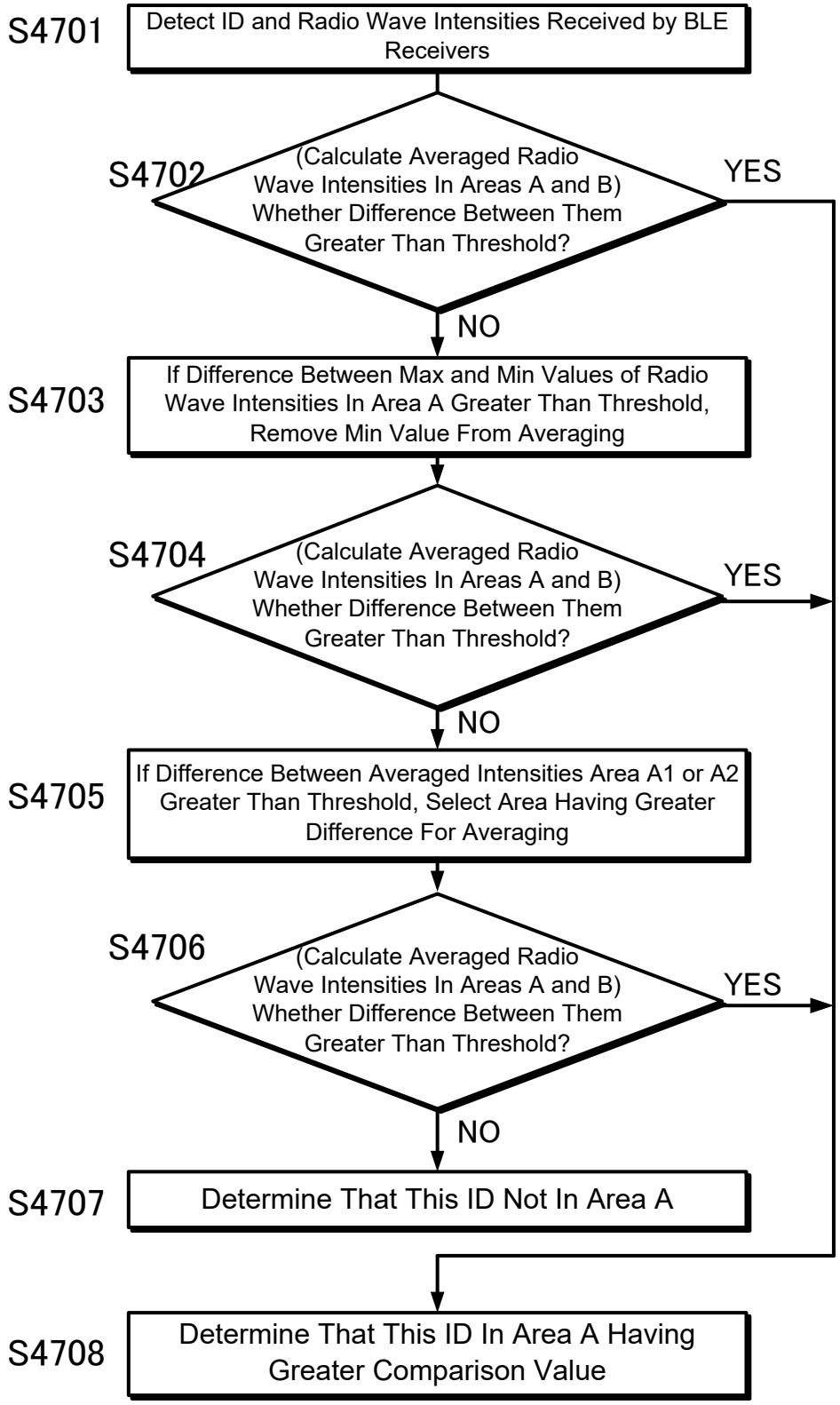

S4701
Detect ID and Radio Wave Intensities Received by BLE Receivers
S4702
(Calculate Averaged Radio Wave Intensities In Areas A and B) Whether Difference Between Them Greater Than Threshold?
YES
NO
S4703
If Difference Between Max and Min Values of Radio Wave Intensities In Area A Greater Than Threshold, Remove Min Value From Averaging
S4704
(Calculate Averaged Radio Wave Intensities In Areas A and B) Whether Difference Between Them Greater Than Threshold?
YES
NO
S4705
If Difference Between Averaged Intensities Area A1 or A2 Greater Than Threshold, Select Area Having Greater Difference For Averaging
S4706
(Calculate Averaged Radio Wave Intensities In Areas A and B) Whether Difference Between Them Greater Than Threshold?
YES
NO
S4707
Determine That This ID Not In Area A
S4708
Determine That This ID In Area A Having Greater Comparison Value

FIG. 48

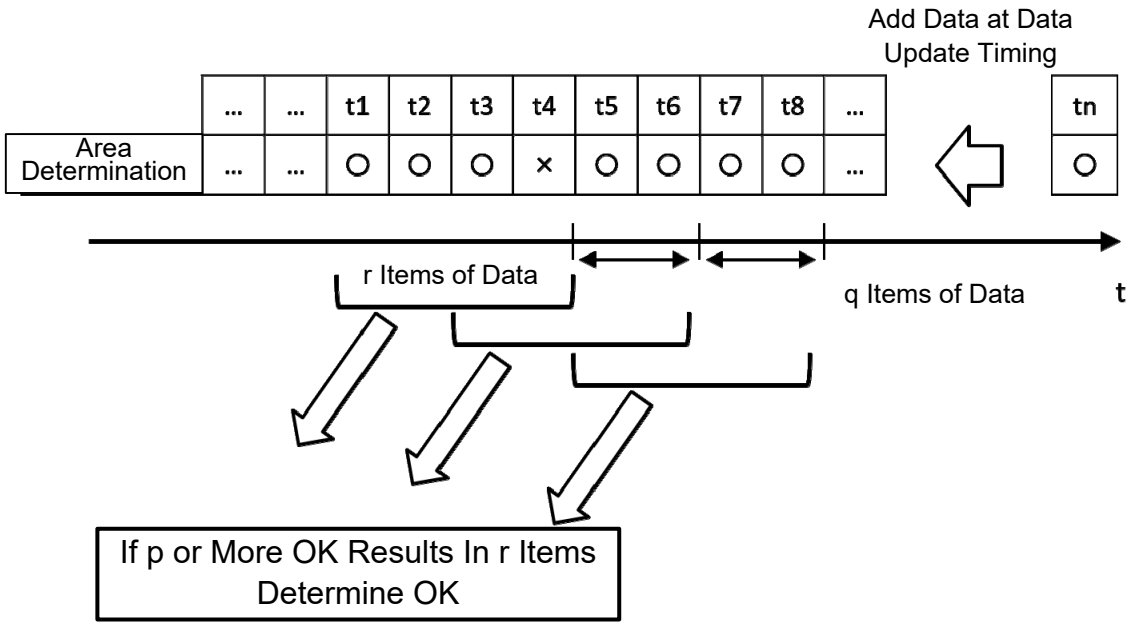

Add Data at Data Update Timing
...
...
t1
t2
t3
t4
t5
t6
t7
t8
...
tn
Area Determination
...
...
○
○
○
×
○
○
○
○
...
○
r Items of Data
q Items of Data
t
If p or More OK Results In r Items Determine OK

FIG. 49

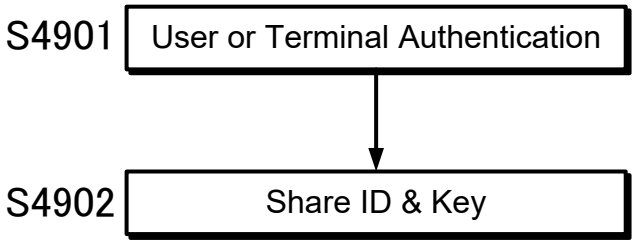

S4901
User or Terminal Authentication
S4902
Share ID & Key

FIG. 50

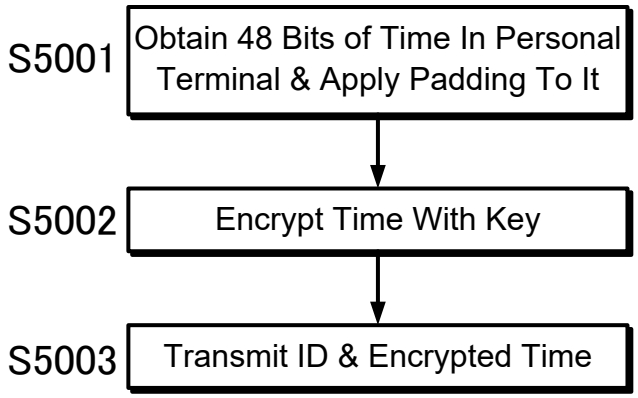

S5001
Obtain 48 Bits of Time In Personal Terminal & Apply Padding To It
S5002
Encrypt Time With Key
S5003
Transmit ID & Encrypted Time

FIG. 51

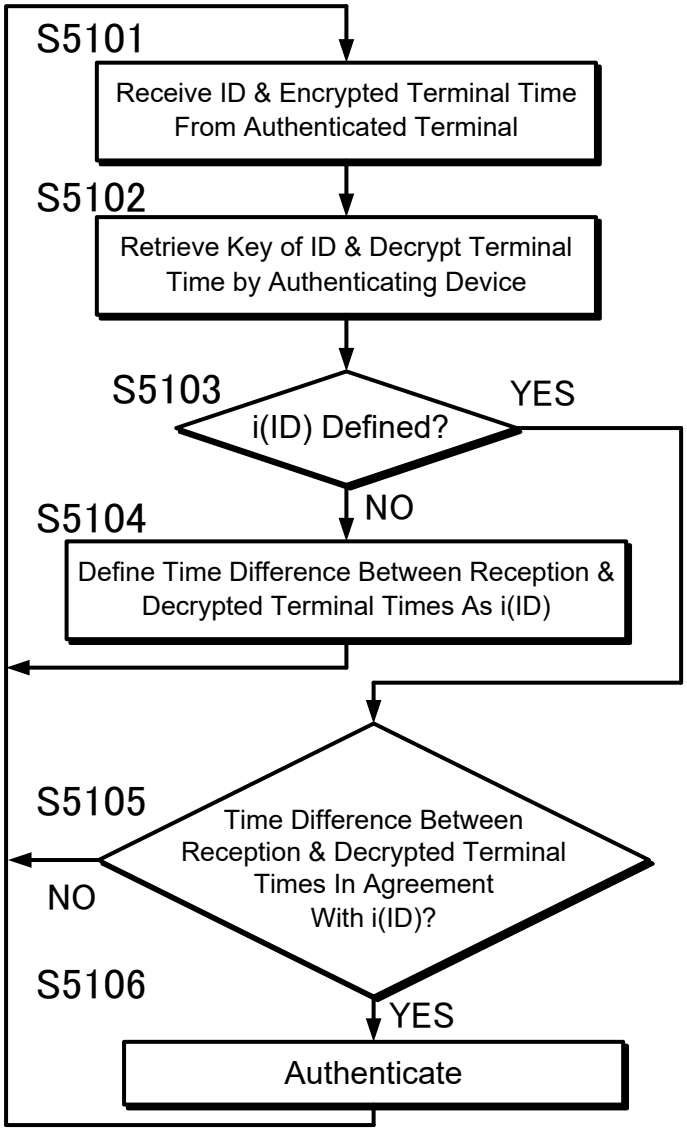

S5101
Receive ID & Encrypted Terminal Time From Authenticated Terminal
S5102
Retrieve Key of ID & Decrypt Terminal Time by Authenticating Device
S5103
i(ID) Defined?
YES
NO
S5104
Define Time Difference Between Reception & Decrypted Terminal Times As i(ID)
S5105
Time Difference Between Reception & Decrypted Terminal Times In Agreement With i(ID)?
NO
S5106
YES
Authenticate

FIG. 52

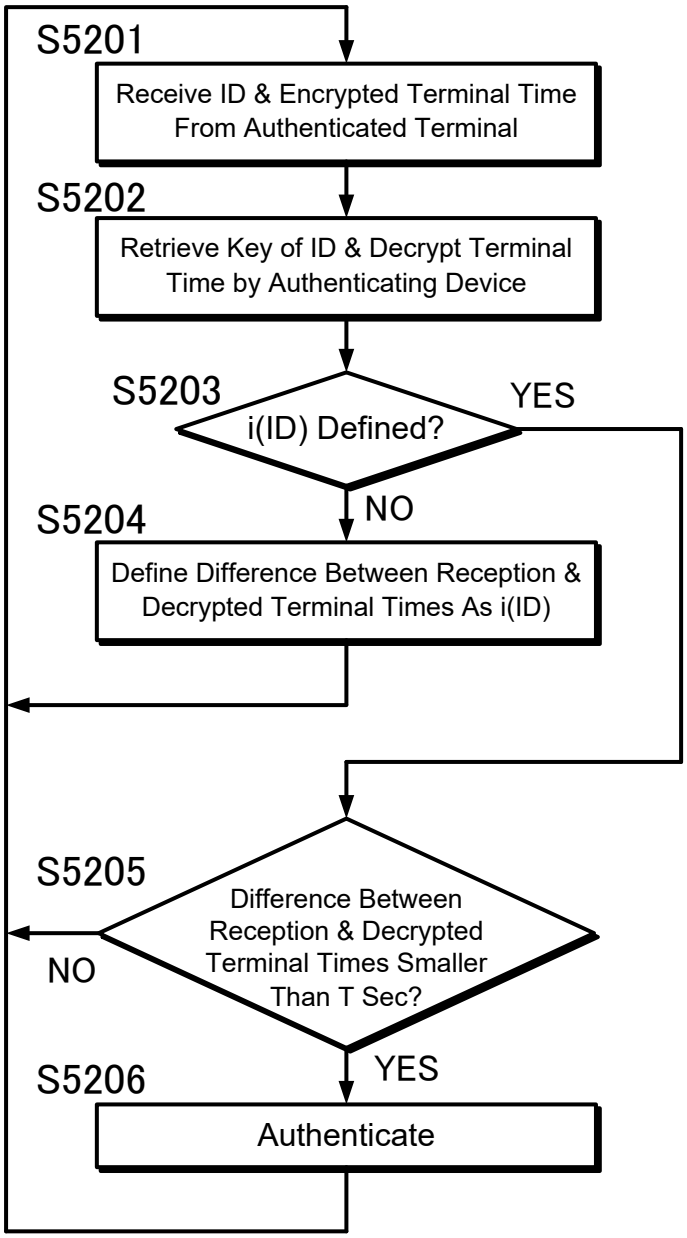

S5201
Receive ID & Encrypted Terminal Time From Authenticated Terminal
S5202
Retrieve Key of ID & Decrypt Terminal Time by Authenticating Device
S5203
i(ID) Defined?
YES
NO
S5204
Define Difference Between Reception & Decrypted Terminal Times As i(ID)
S5205
Difference Between Reception & Decrypted Terminal Times Smaller Than T Sec?
NO
YES
S5206
Authenticate

FIG. 53

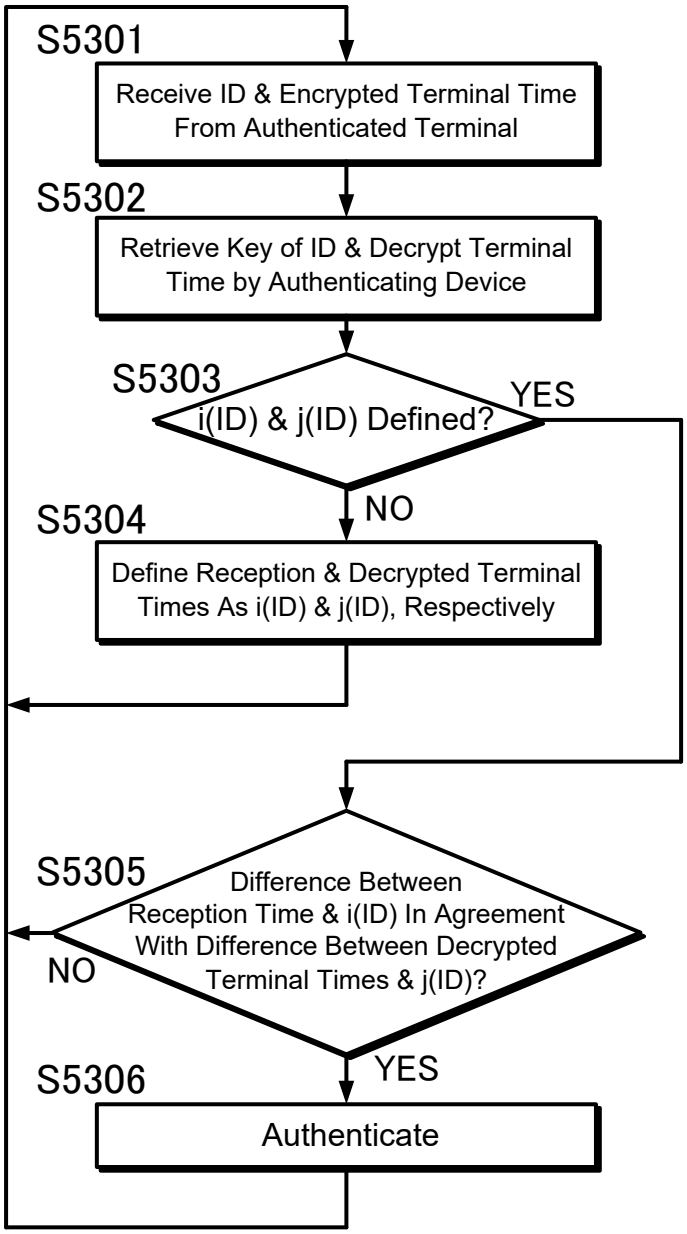

S5301
Receive ID & Encrypted Terminal Time From Authenticated Terminal
S5302
Retrieve Key of ID & Decrypt Terminal Time by Authenticating Device
S5303
i(ID) & j(ID) Defined?
YES
NO
S5304
Define Reception & Decrypted Terminal Times As i(ID) & j(ID), Respectively
S5305
Difference Between Reception Time & i(ID) In Agreement With Difference Between Decrypted Terminal Times & j(ID)?
NO
YES
S5306
Authenticate

FIG. 54

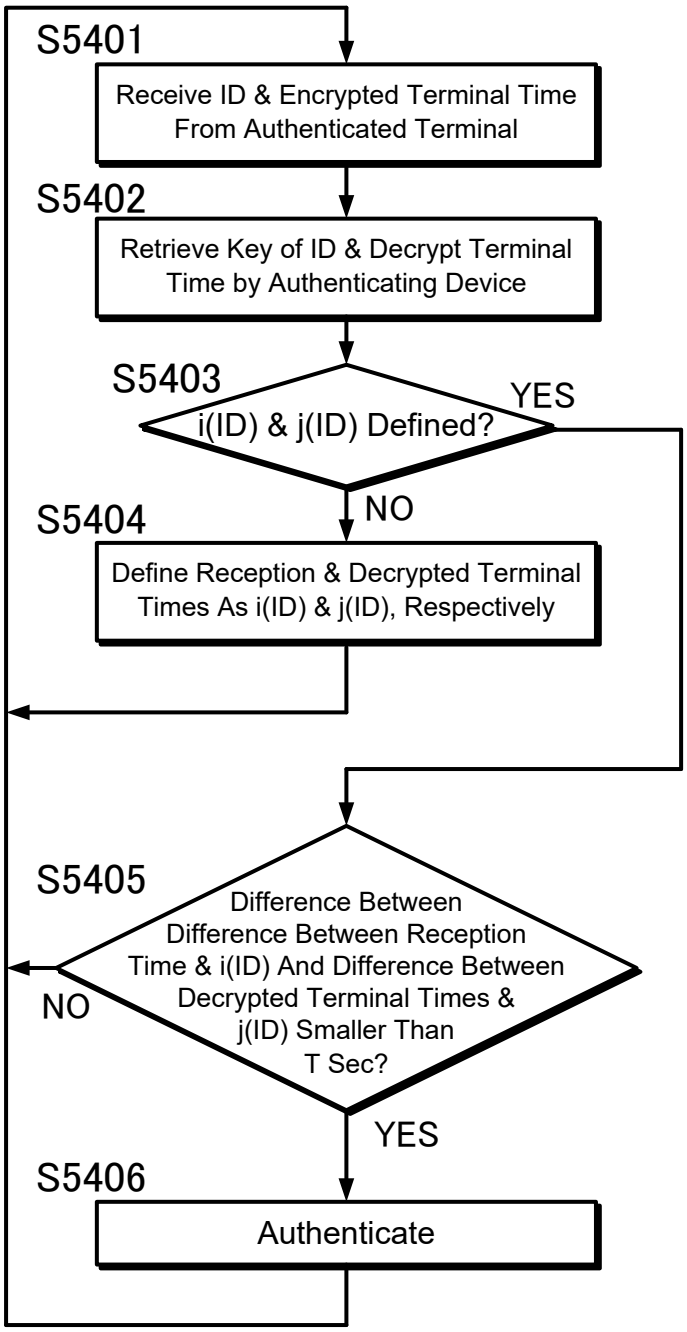

S5401
Receive ID & Encrypted Terminal Time From Authenticated Terminal
S5402
Retrieve Key of ID & Decrypt Terminal Time by Authenticating Device
S5403
i(ID) & j(ID) Defined?
YES
NO
S5404
Define Reception & Decrypted Terminal Times As i(ID) & j(ID), Respectively
S5405
Difference Between Difference Between Reception Time & i(ID) And Difference Between Decrypted Terminal Times & j(ID) Smaller Than T Sec?
NO
YES
S5406
Authenticate

FIG. 55

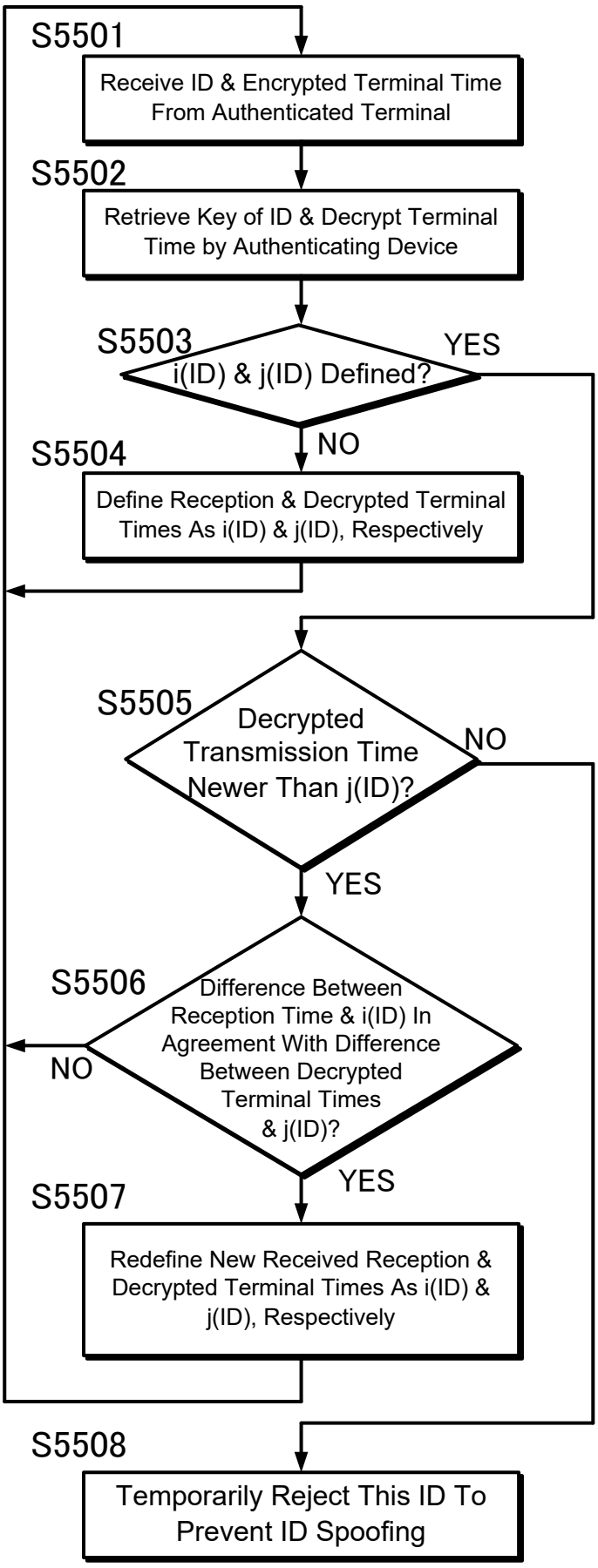

S5501
Receive ID & Encrypted Terminal Time From Authenticated Terminal
S5502
Retrieve Key of ID & Decrypt Terminal Time by Authenticating Device
S5503
i(ID) & j(ID) Defined?
YES
NO
S5504
Define Reception & Decrypted Terminal Times As i(ID) & j(ID), Respectively
S5505
Decrypted Transmission Time Newer Than j(ID)?
NO
YES
S5506
Difference Between Reception Time & i(ID) In Agreement With Difference Between Decrypted Terminal Times & j(ID)?
NO
YES
S5507
Redefine New Received Reception & Decrypted Terminal Times As i(ID) & j(ID), Respectively
S5508
Temporarily Reject This ID To Prevent ID Spoofing

FIG. 56

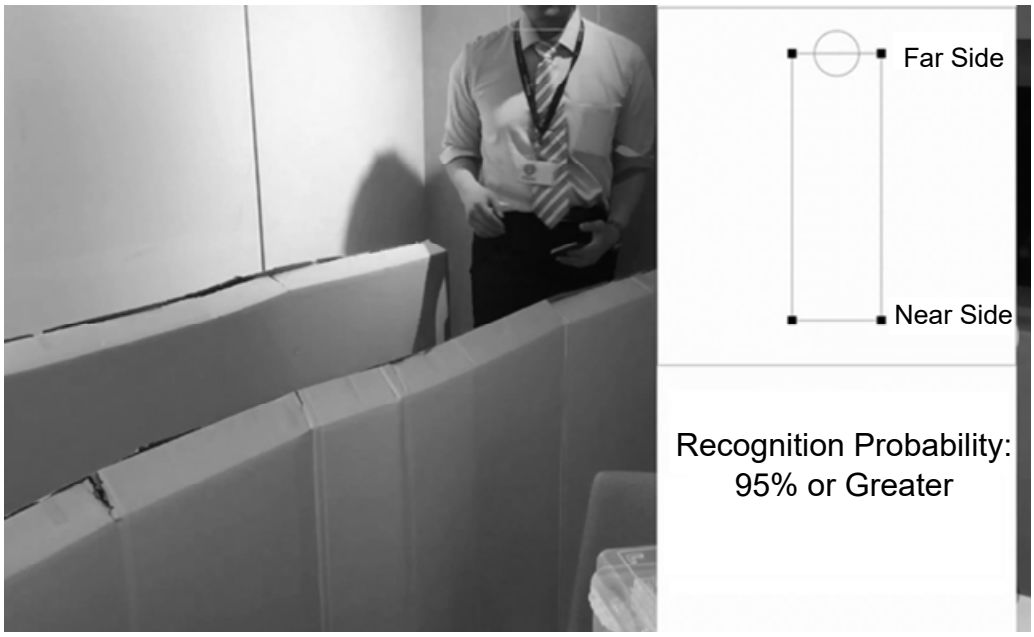

Far Side
Near Side
Recognition Probability:
95% or Greater

FIG. 57

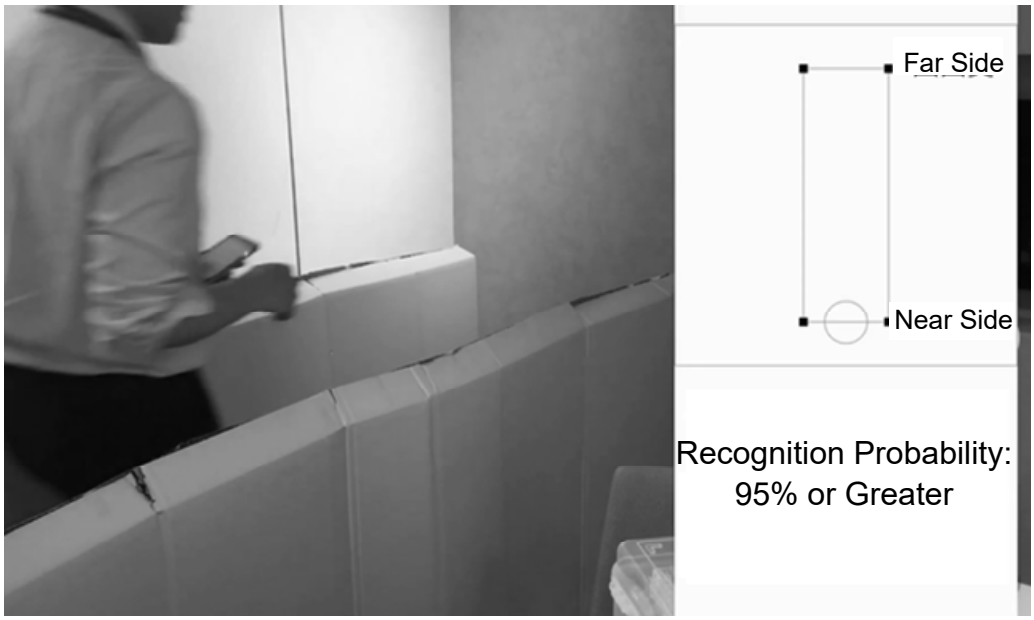

Far Side
Near Side
Recognition Probability:
95% or Greater

FIG. 58

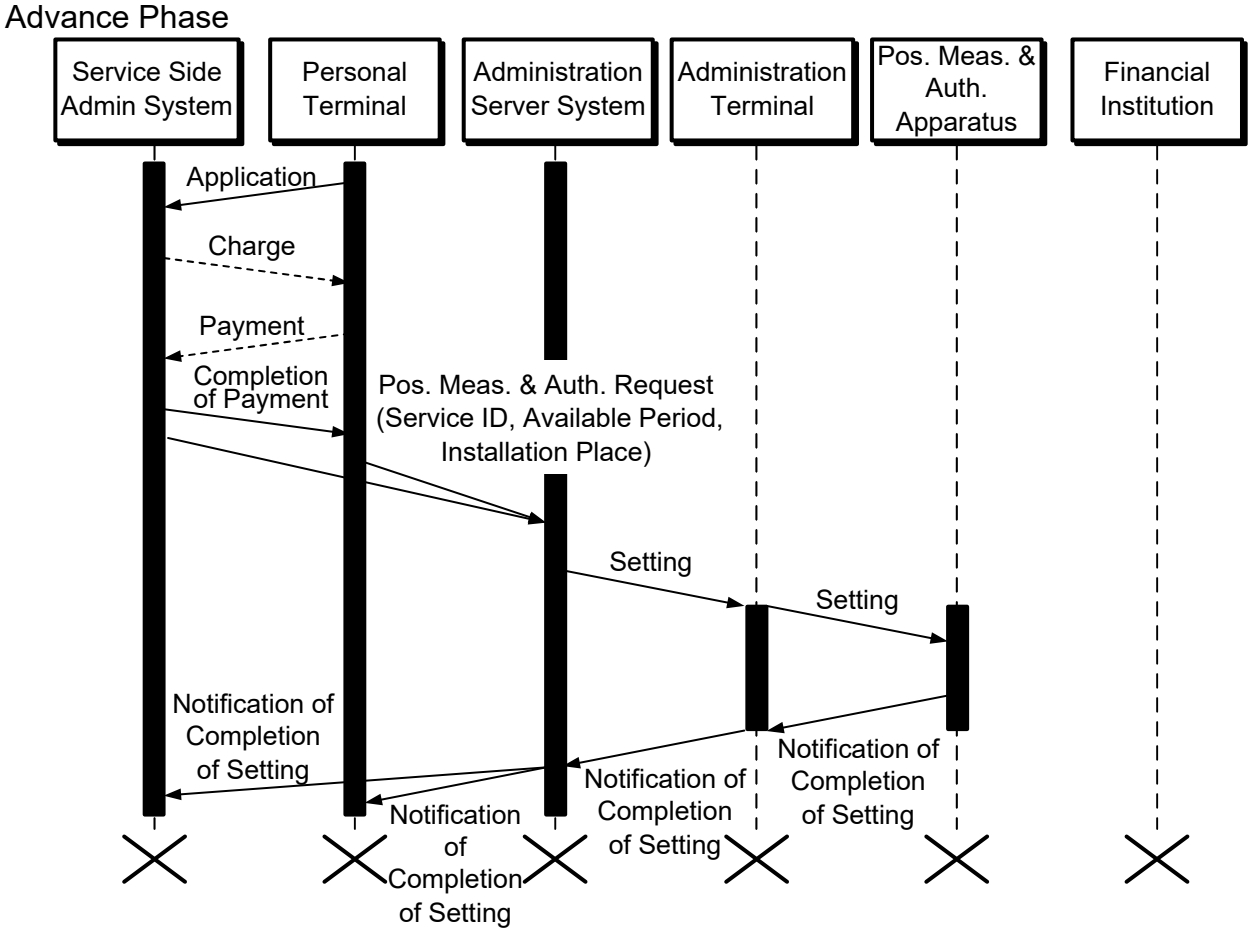
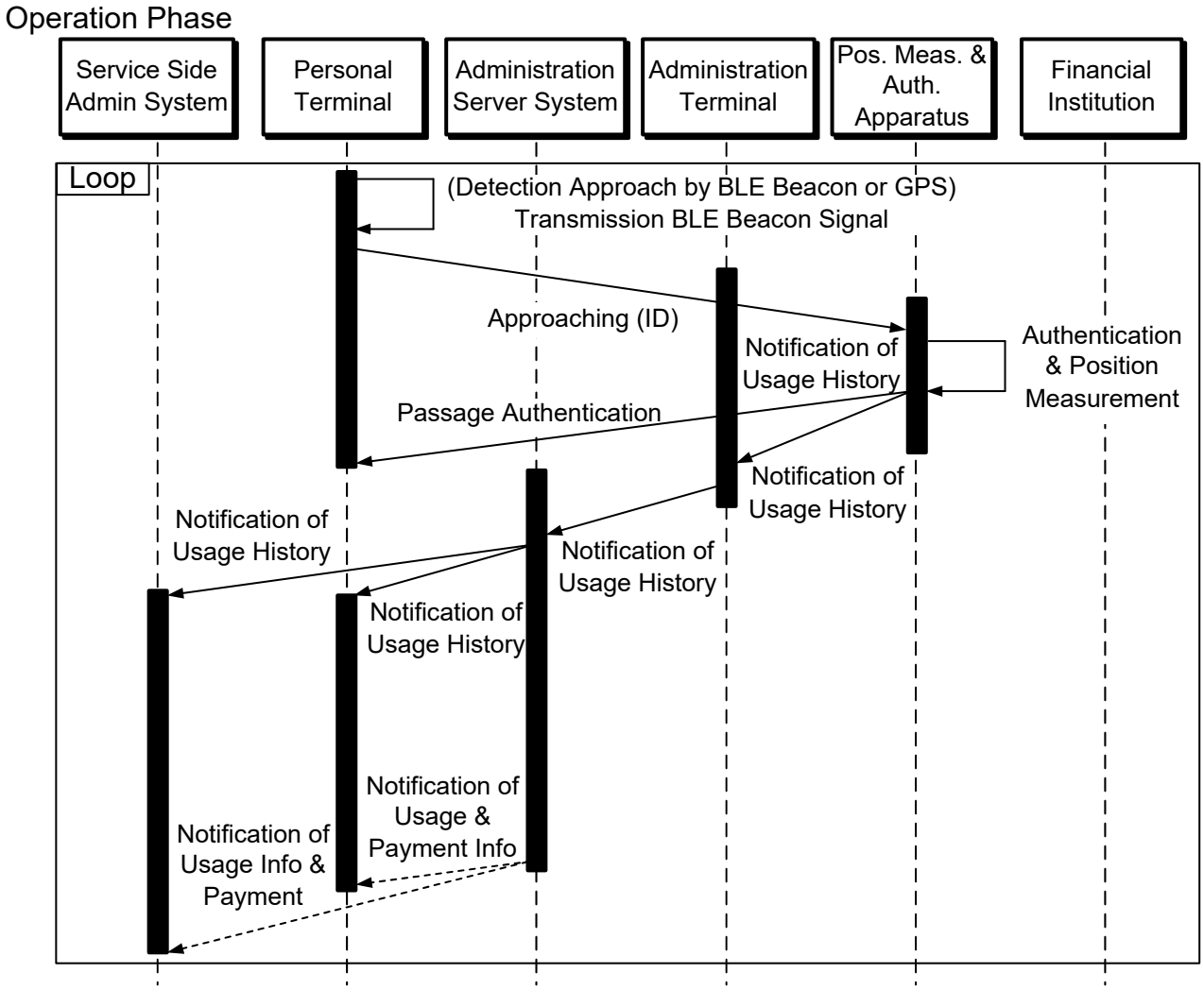

Advance Phase
Service Side Admin System
Personal Terminal
Administration Server System
Administration Terminal
Pos. Meas. & Auth. Apparatus
Financial Institution
Application
Charge
Payment
Completion of Payment
Pos. Meas. & Auth. Request (Service ID, Available Period, Installation Place)
Setting
Setting
Notification of Completion of Setting
Notification of Completion of Setting
Notification of Completion of Setting
Notification of Completion of Setting

FIG. 59


Operation Phase
Service Side Admin System
Personal Terminal
Administration Server System
Administration Terminal
Pos. Meas. & Auth. Apparatus
Financial Institution
Loop
(Detection Approach by BLE Beacon or GPS)
Transmission BLE Beacon Signal
Approaching (ID)
Notification of Usage History
Authentication & Position Measurement
Passage Authentication
Notification of Usage History
Notification of Usage History
Notification of Usage History
Notification of Usage History
Notification of Usage & Payment Info
Notification of Usage Info & Payment