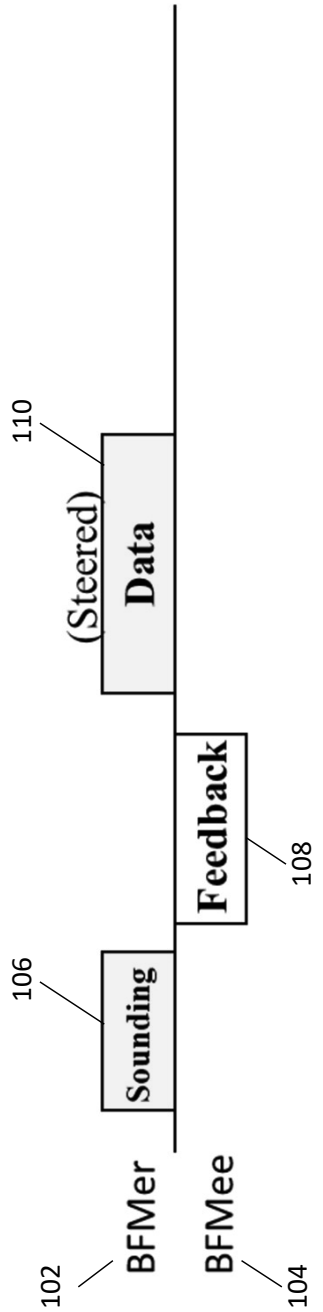

110
(Steered)
Data
Feedback
108
106
Sounding
BFMer
BFMee
102
104

100

Figure 1

Field	Size (bits)	Meaning
SNR in receive chain 1	8	Signal-to-noise ratio in the first receive chain of the STA sending the report.
...		
SNR in receive chain *Nr*	8	Signal-to-noise ratio in the *Nr*'th receive chain of the STA sending the report.
CSI Matrix for carrier –28	3+2× *Nb*×*Nc*×*Nr*	CSI matrix (see Figure 9-112 (CSI matrix coding))
...		
CSI Matrix for carrier –1	3+2× *Nb*×*Nc*×*Nr*	CSI matrix
CSI Matrix for carrier 1	3+2× *Nb*×*Nc*×*Nr*	CSI matrix
...		
CSI Matrix for carrier 28	3+2× *Nb*×*Nc*×*Nr*	CSI matrix

200

Table 9-56—CSI Report field (20 MHz)

Figure 2A

CSI Field Parameters	Meaning	Range of Values
Nb	Number of Bits for I or Q	{4, 5, 6, 8}
Nc	Number of Columns	0 to 3
Nr	Number of Rows	1 to 4
Ng	Grouping	{1, 2, 4}

202

Figure 2B

Table 9-91a—HE MIMO Control field encoding

Subfield	Description
Nc Index	If the Feedback Type subfield indicates SU or MU, the Nc Index subfield indicates the number of columns, *Nc*, in the compressed beamforming feedback matrix and is set to *Nc* – 1. If the Feedback Type subfield indicates CQI, the Nc Index subfield indicates the number of space time streams, *Nc*, in the CQI Report and is set to *Nc* – 1.
Nr Index	If the Feedback Type subfield indicates SU or MU, then the Nr Index subfield indicates the number of rows, *Nr*, in the compressed beamforming feedback matrix and is set to *Nr* – 1.The value 0 is reserved. If the Feedback Type subfield indicates CQI, then the Nr Index subfield is reserved.



Figure 3

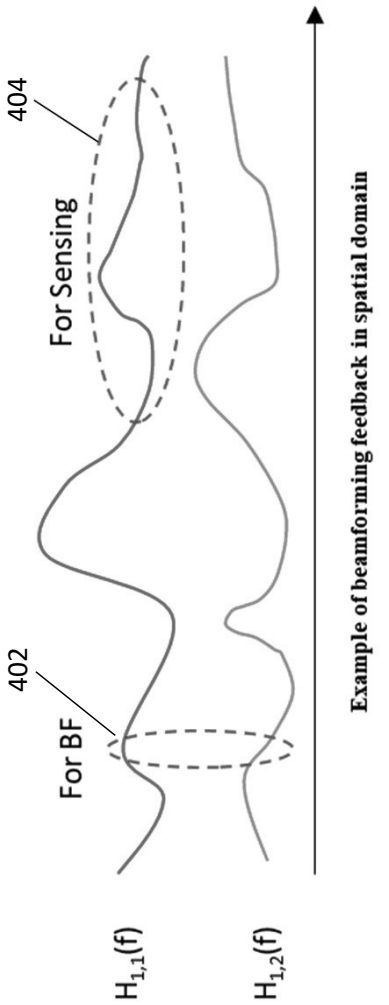


Figure 4A

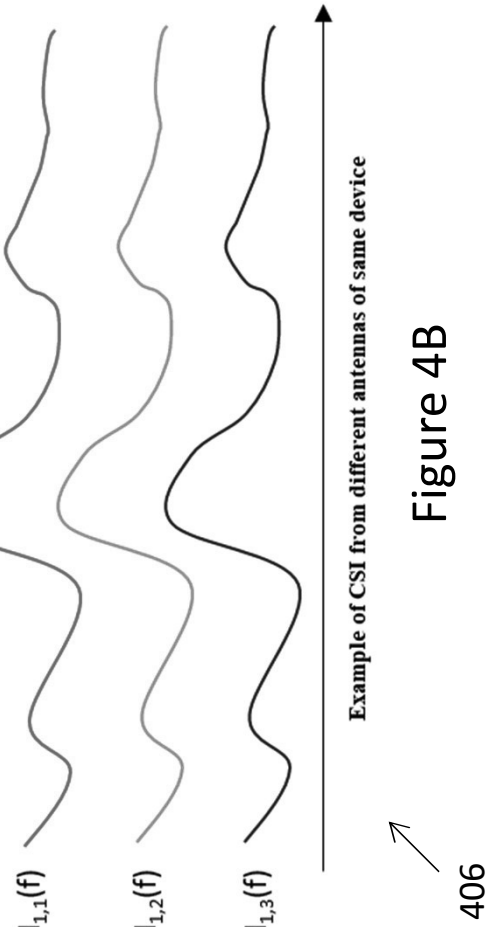


Figure 4B

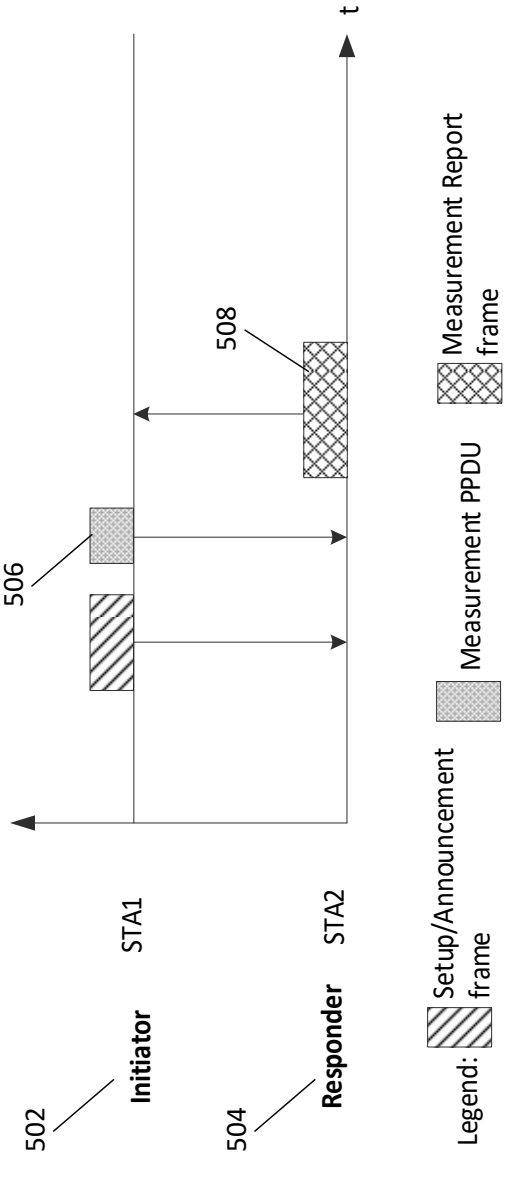

t
508
506
Measurement Report frame
Measurement PPDU
Setup/Announcement frame
Legend:
502
Initiator
STA1
504
Responder
STA2
500

Figure 5

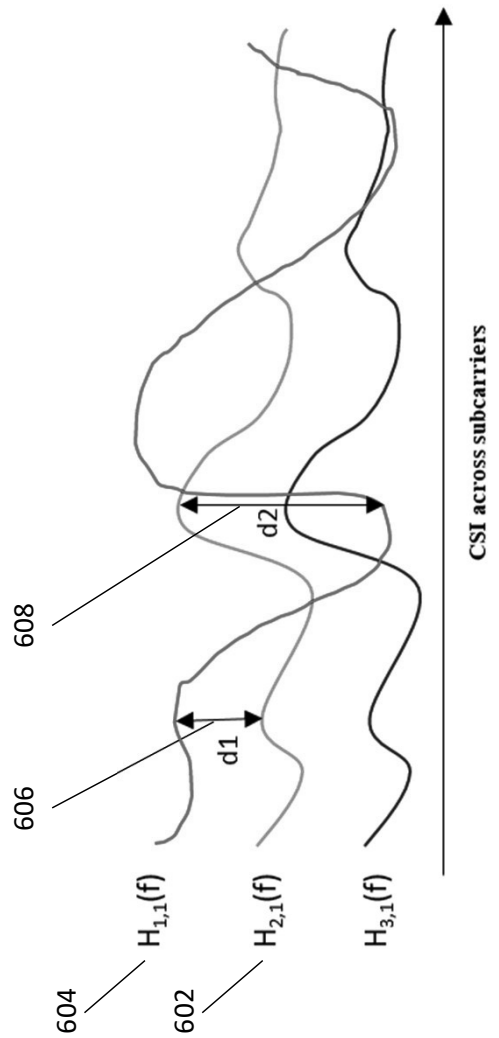

CSI across subcarriers
$H_{1,1}(f)$
$H_{2,1}(f)$
$H_{3,1}(f)$
d1
d2
604
602
606
608
600

Figure 6

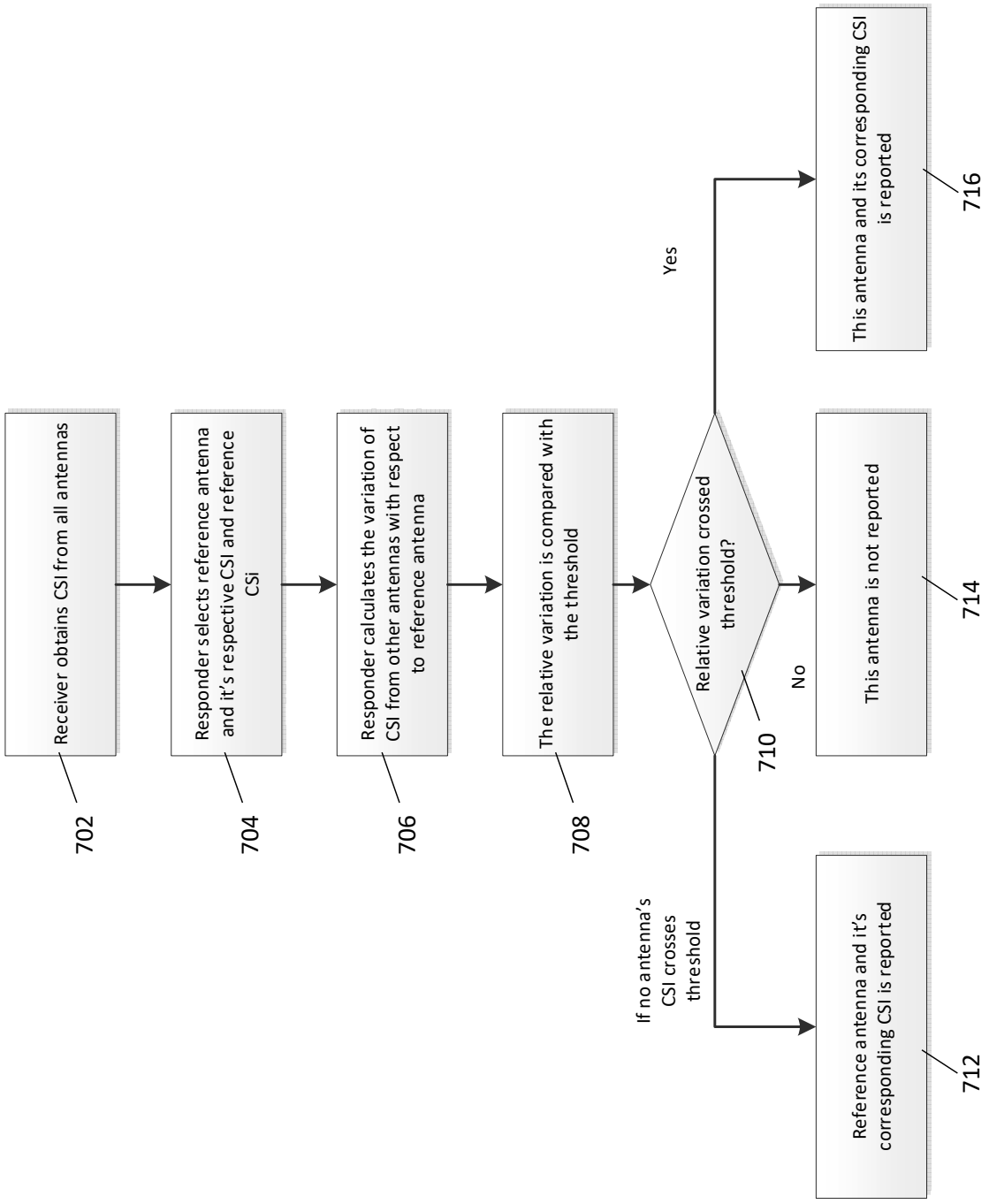

Receiver obtains CSI from all antennas
Responder selects reference antenna and it's respective CSI and reference CSi
Responder calculates the variation of CSI from other antennas with respect to reference antenna
The relative variation is compared with the threshold
Relative variation crossed threshold?
Yes
No
If no antenna's CSI crosses threshold
This antenna and its corresponding CSI is reported
This antenna is not reported
Reference antenna and it's corresponding CSI is reported
702
704
706
708
710
712
714
716

Figure 7

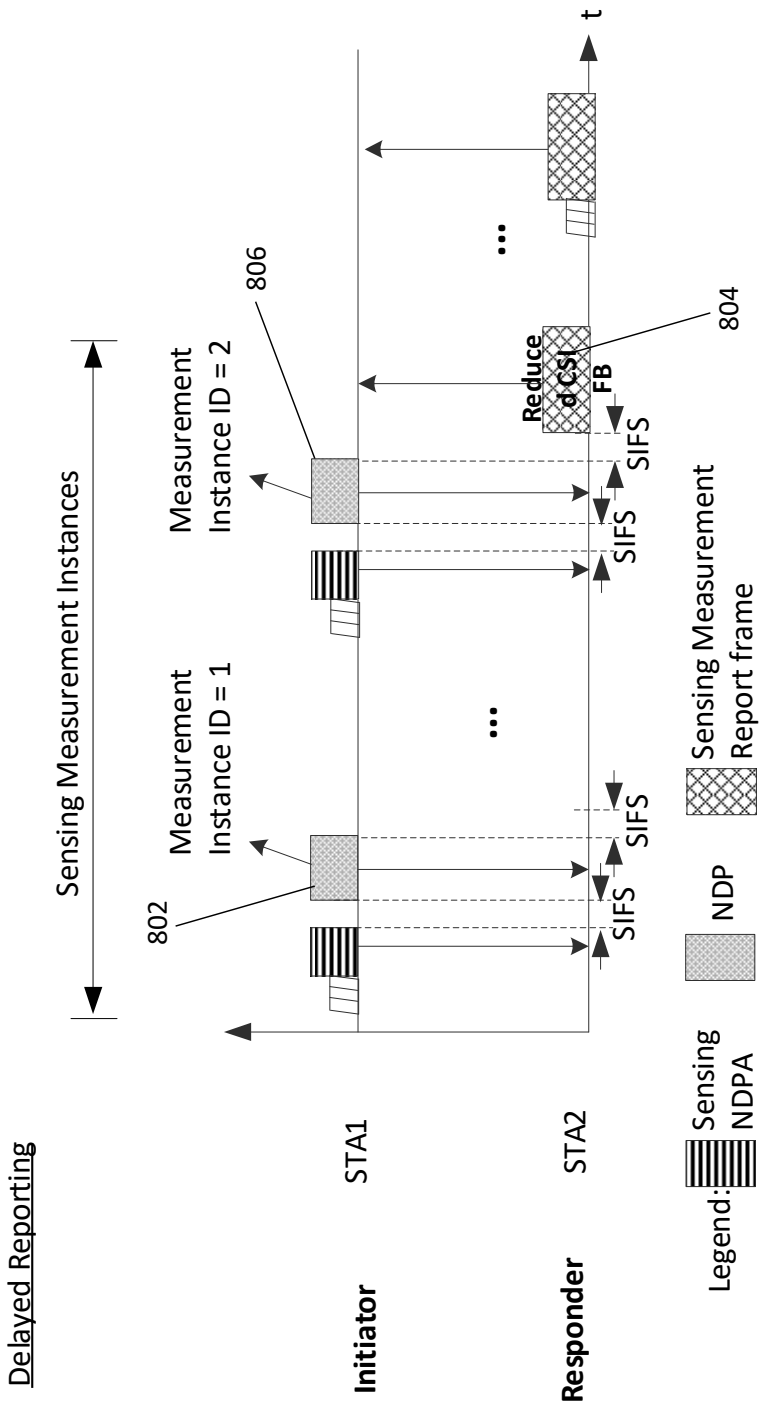

Delayed Reporting
Sensing Measurement Instances
Measurement Instance ID = 1
Measurement Instance ID = 2
802
806
804
Reduce d CSI FB
SIFS
SIFS
SIFS
SIFS
Sensing Measurement Report frame
NDP
Sensing NDPA
Legend:
Initiator
STA1
Responder
STA2
t
800

Figure 8

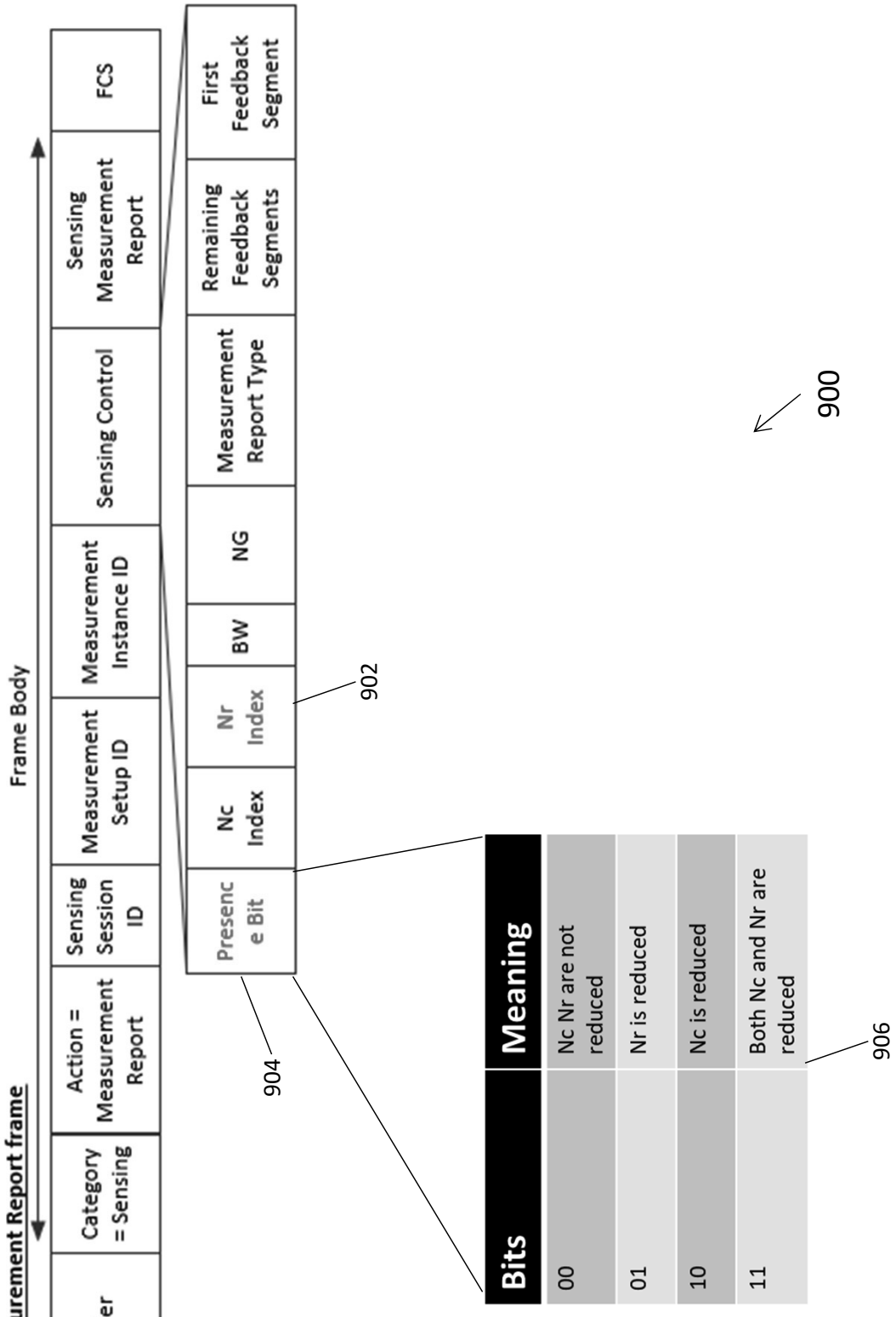

Sensing Measurement Report frame
MAC Header
Category = Sensing
Action = Measurement Report
Sensing Session ID
Measurement Setup ID
Measurement Instance ID
Sensing Control
Sensing Measurement Report
FCS
Frame Body
Presence Bit
Nc Index
Nr Index
BW
NG
Measurement Report Type
Remaining Feedback Segments
First Feedback Segment
902
904
900
906
Bits
Meaning
00
Nc Nr are not reduced
01
Nr is reduced
10
Nc is reduced
11
Both Nc and Nr are reduced

Figure 9

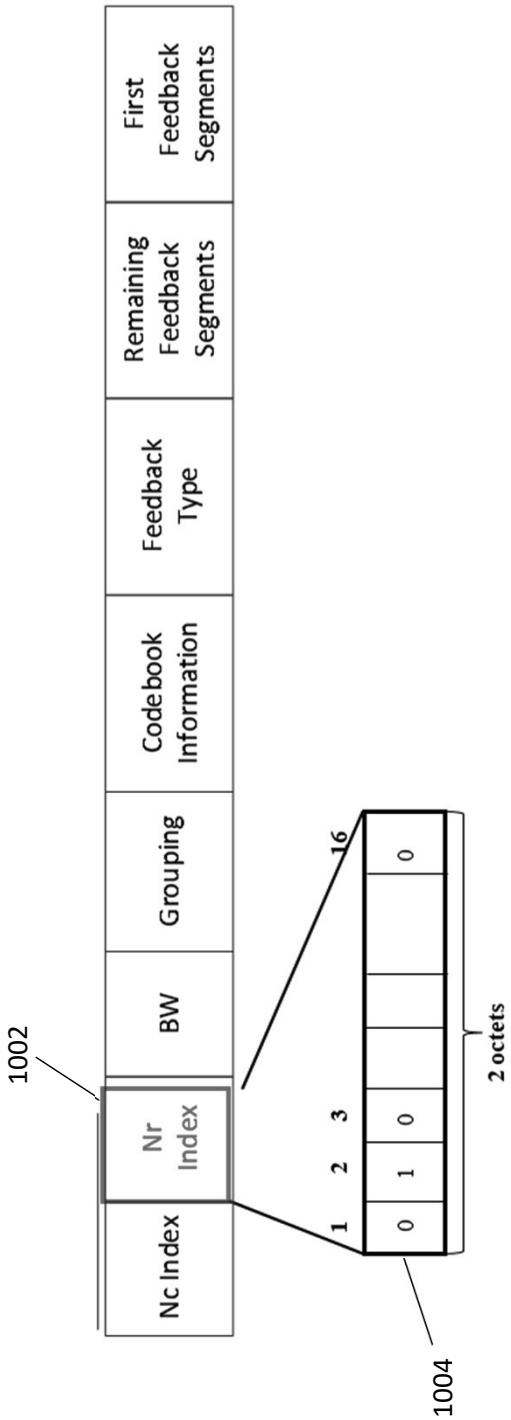

1002
Nc Index
Nr Index
BW
Grouping
Codebook Information
Feedback Type
Remaining Feedback Segments
First Feedback Segments
1
2
3
16
0
1
0
0
2 octets
1004
1000

Figure 10

Feedback Bit size (Nb)	Total receive antennas (Nr)	Reported antennas (Nr)	Total bit size of 11n based feedback $Ns * (3 + 2 * Nb * Nr * Nc) bits$	Total bit size of Reduced antenna reporting feedback $Ns * (3 + 2 * Nb * Nr * Nc) bits$	%Difference
4	2	1	131	67	48.85
6	4	2	387	195	49.61
8	8	4	1027	515	49.85
8	8	7	1027	899	12.46

1102

1104

1100

Figure 11

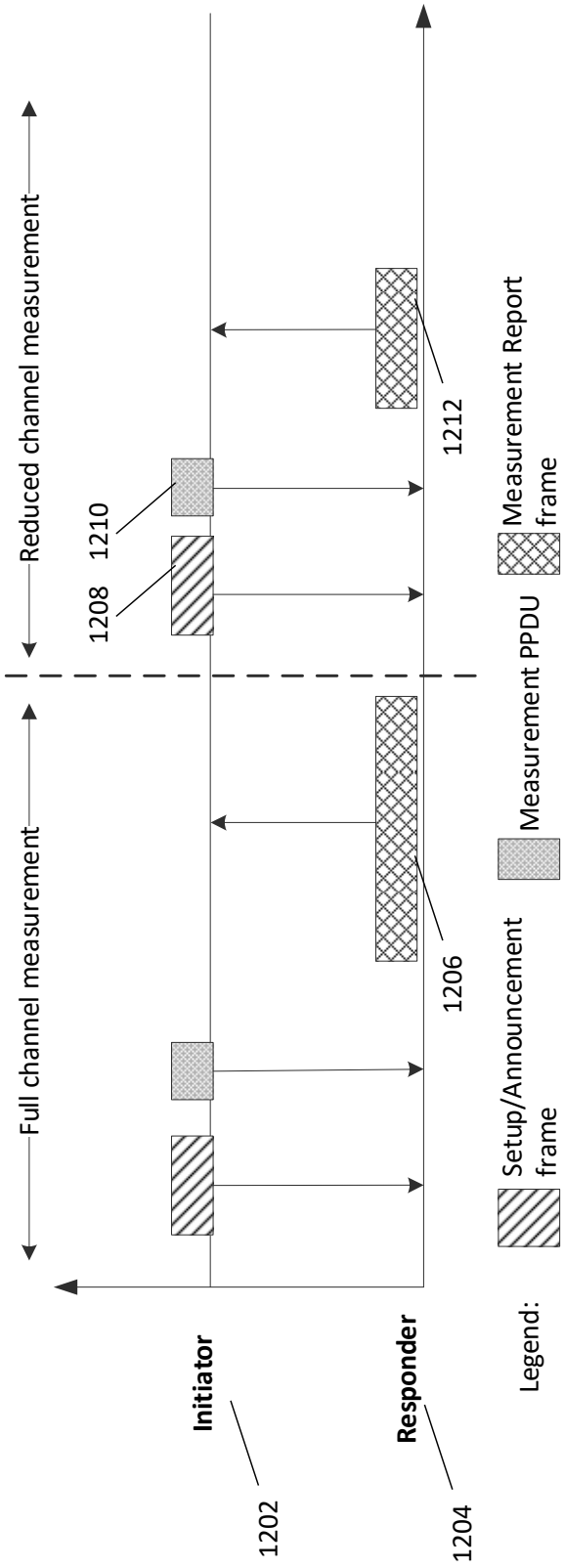

Reduced channel measurement
Full channel measurement
1208
1210
1212
1206
Initiator
Responder
1202
1204
Legend:
Setup/Announcement frame
Measurement PPDU
Measurement Report frame
1200

Figure 12

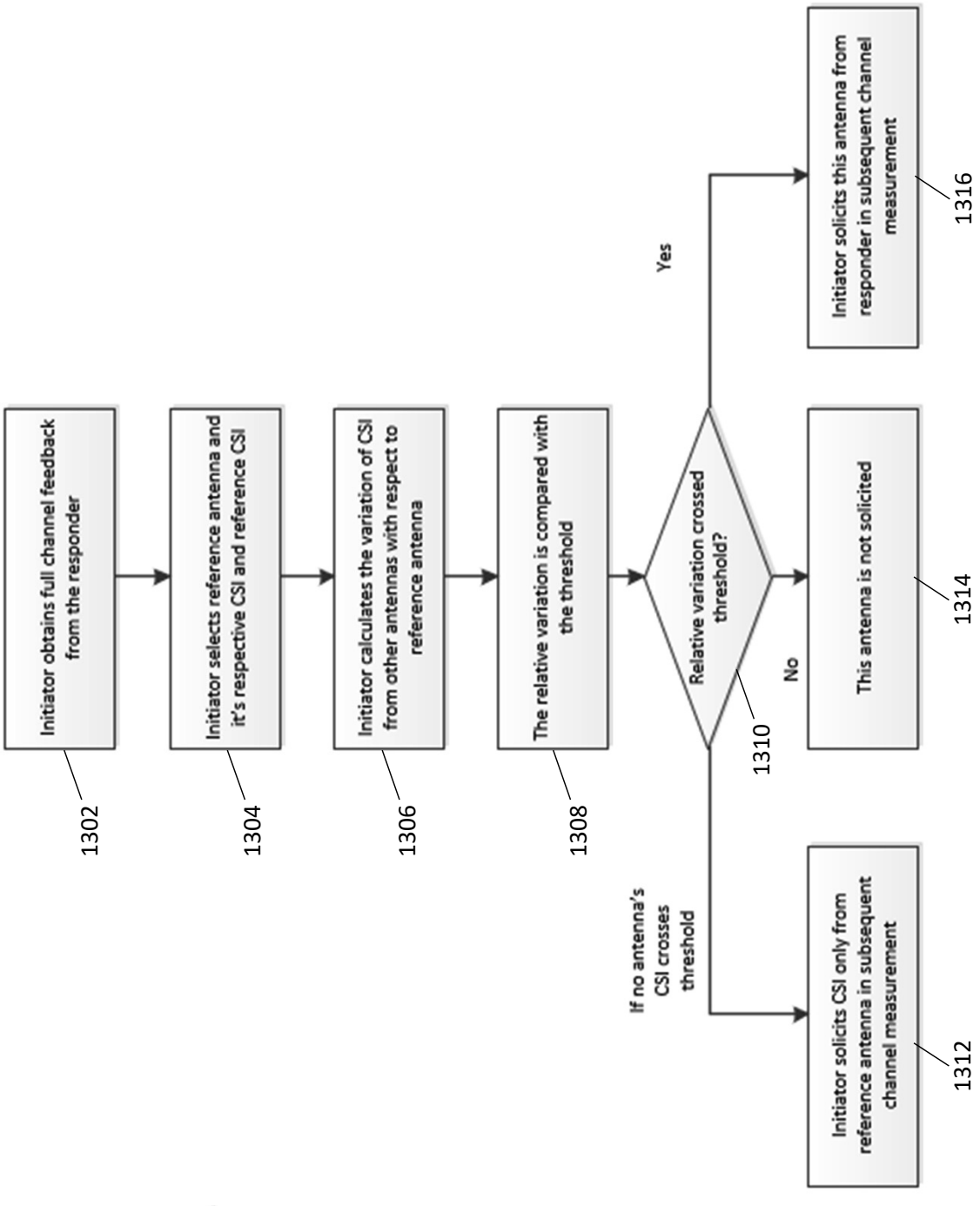

Initiator obtains full channel feedback from the responder
Initiator selects reference antenna and it's respective CSI and reference CSI
Initiator calculates the variation of CSI from other antennas with respect to reference antenna
The relative variation is compared with the threshold
Relative variation crossed threshold?
Yes
No
If no antenna's CSI crosses threshold
Initiator solicits this antenna from responder in subsequent channel measurement
This antenna is not solicited
Initiator solicits CSI only from reference antenna in subsequent channel measurement
1302
1304
1306
1308
1310
1312
1314
1316
1300

Figure 13

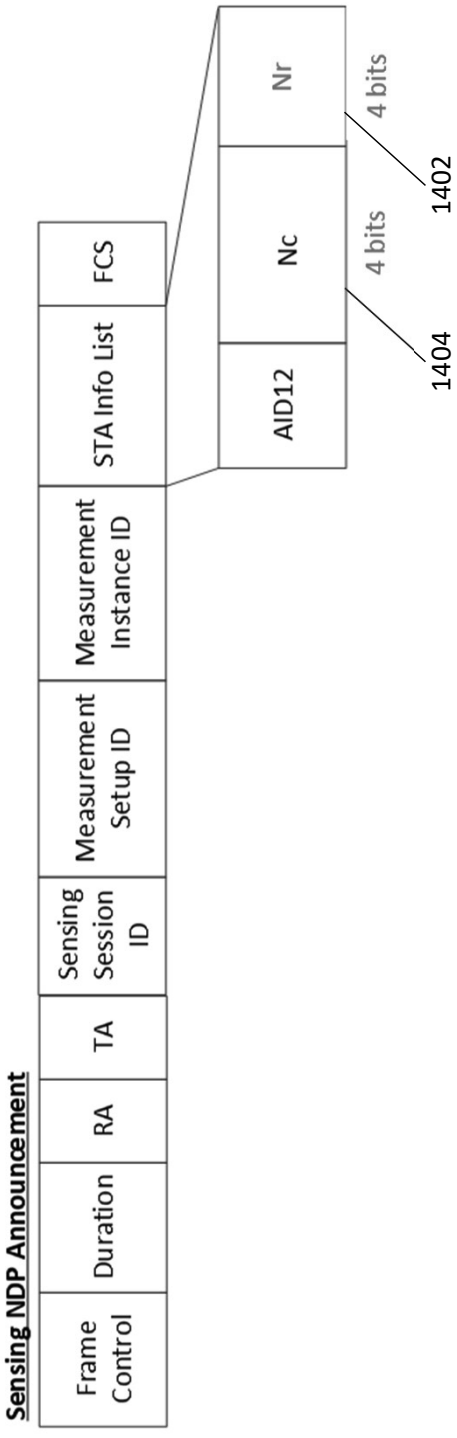
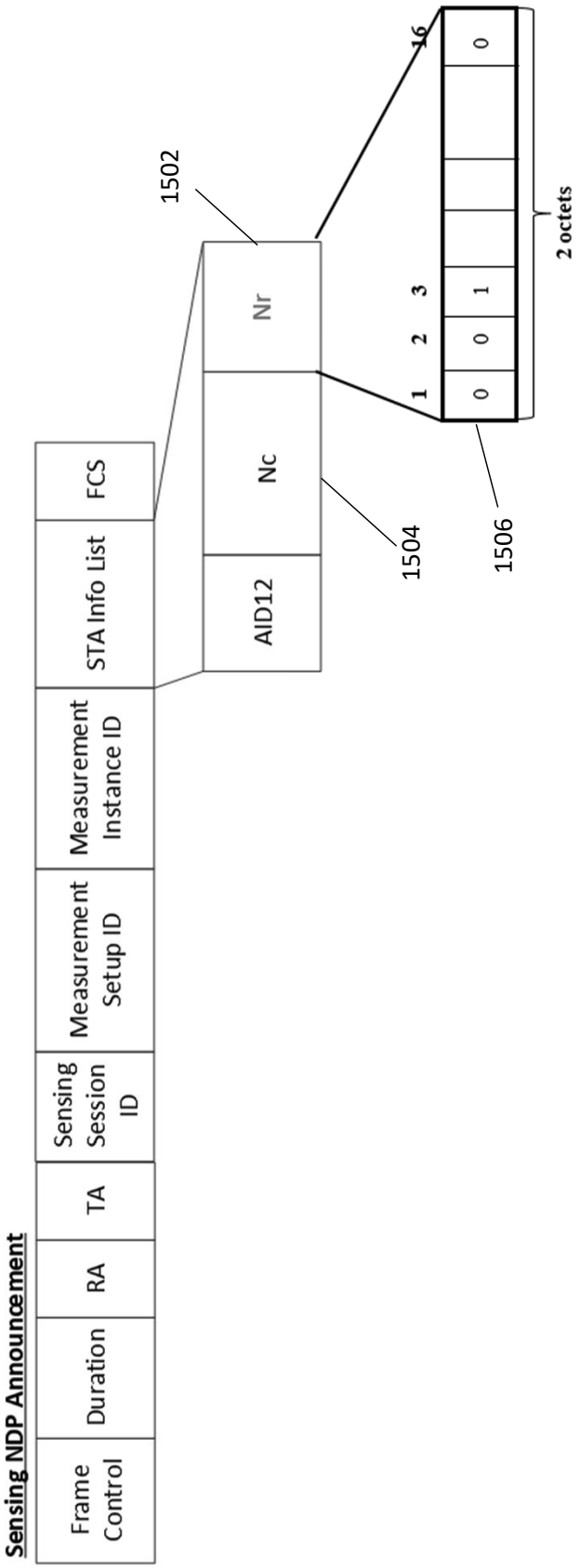

Sensing NDP Announcement
Frame Control
Duration
RA
TA
Sensing Session ID
Measurement Setup ID
Measurement Instance ID
STA Info List
FCS
AID12
Nc
Nr
4 bits
4 bits
1402
1404
1400

Figure 14



1500

Figure 15

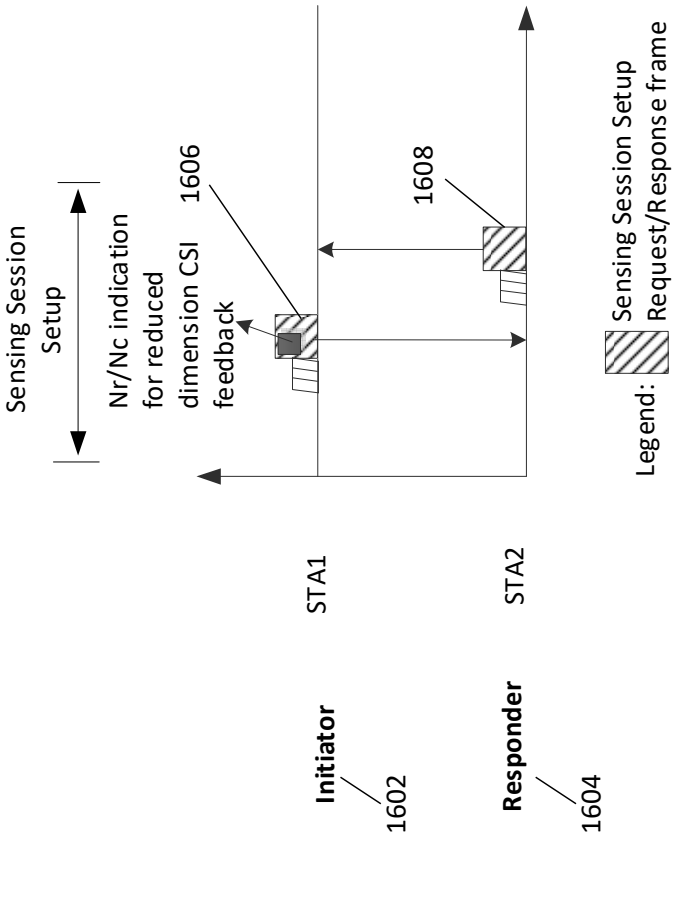
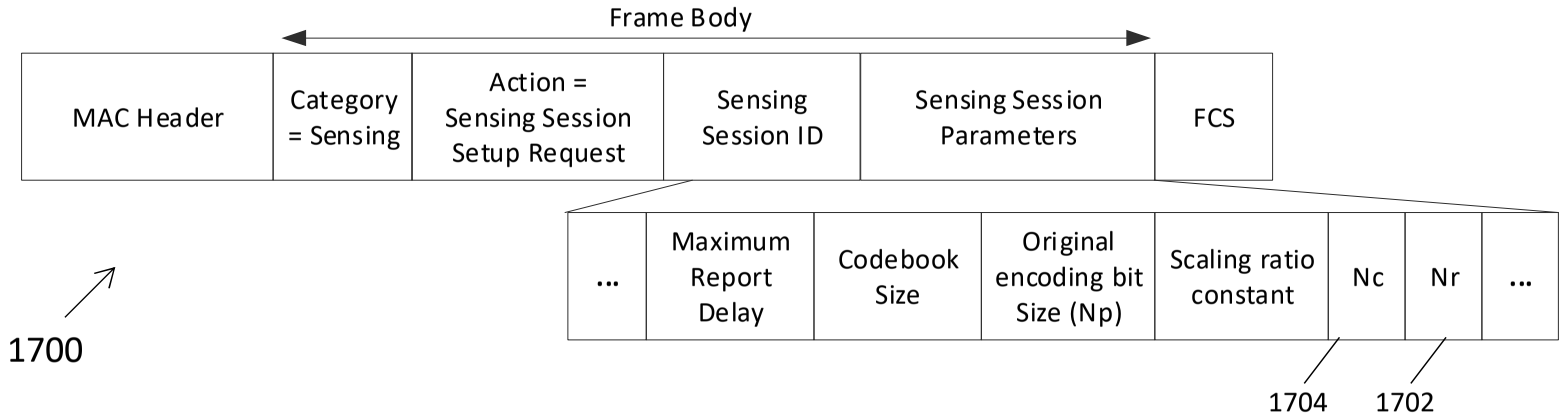

Sensing Session Setup
Nr/Nc indication for reduced dimension CSI feedback
1606
1608
Initiator
1602
STA1
Responder
1604
STA2
Legend:
Sensing Session Setup Request/Response frame
1600

Figure 16

Sensing Session Setup Request frame



Sensing Session Setup Response frame

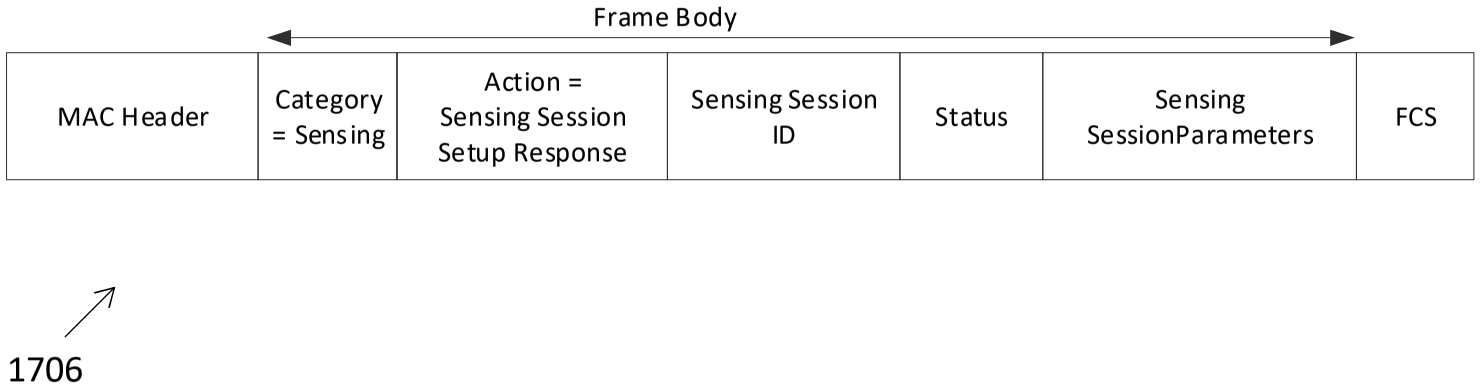


Figure 17

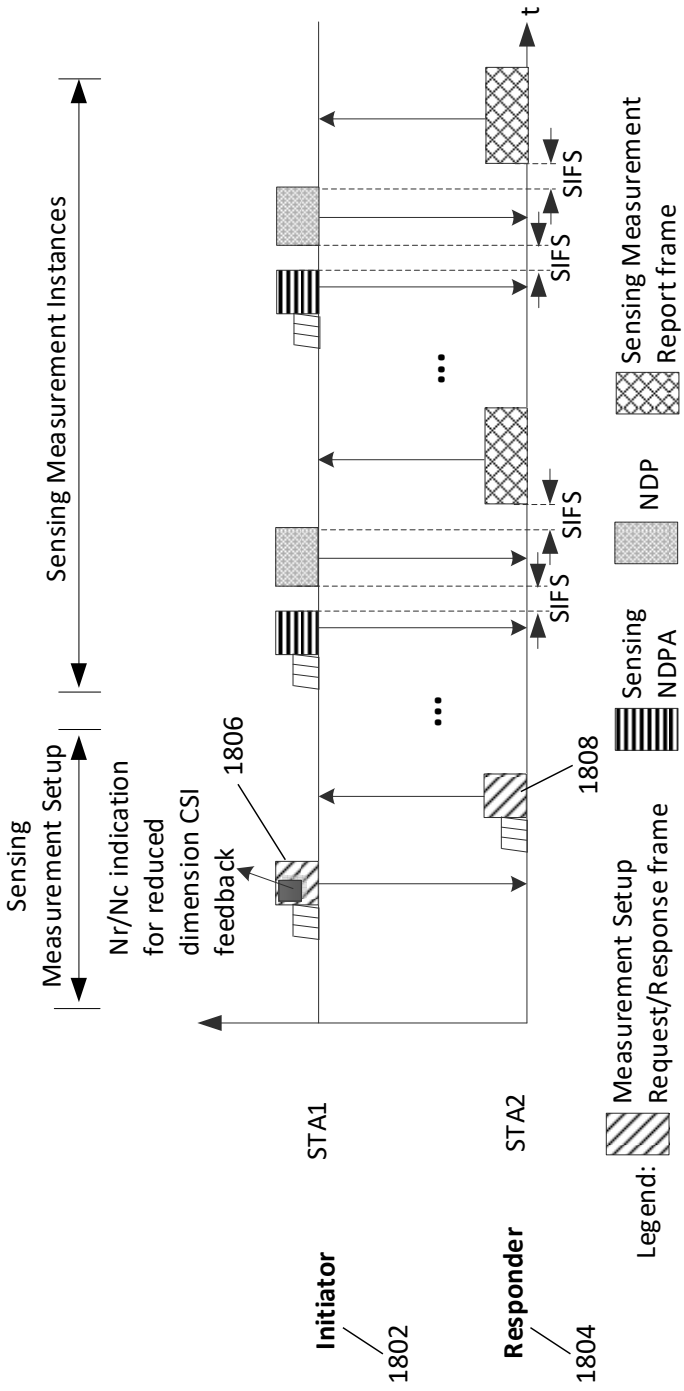
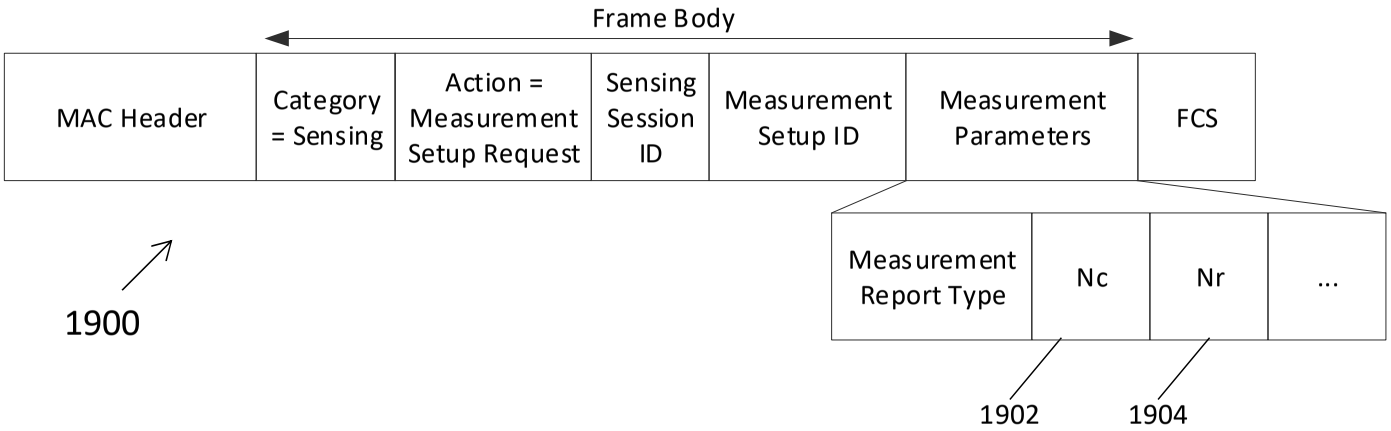

Sensing Measurement Instances
Sensing Measurement Setup
Nr/Nc indication for reduced dimension CSI feedback
1806
1808
SIFS
SIFS
SIFS
SIFS
t
Sensing Measurement Report frame
NDP
Sensing NDPA
Measurement Setup Request/Response frame
Legend:
STA1
STA2
Initiator
1802
Responder
1804
1800

Figure 18

Sensing Measurement Setup Request frame



Sensing Measurement Setup Response frame

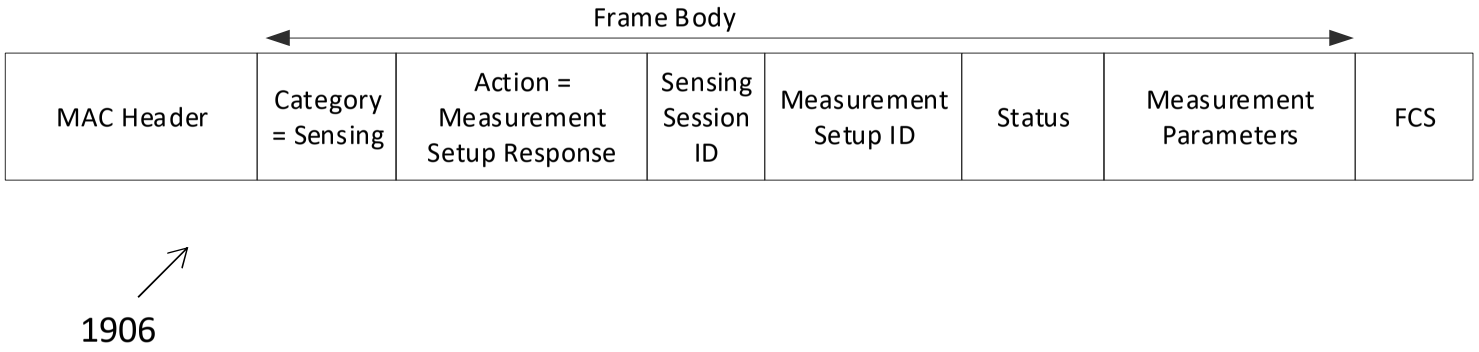
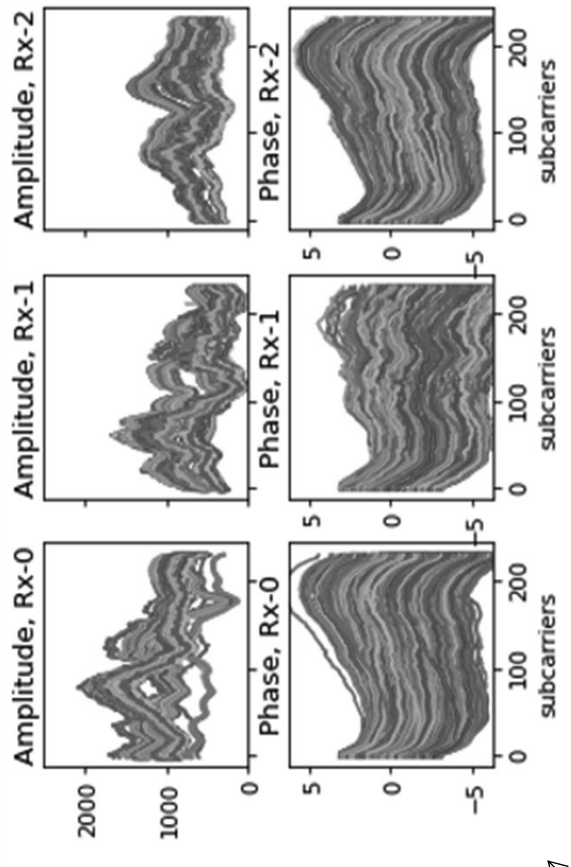
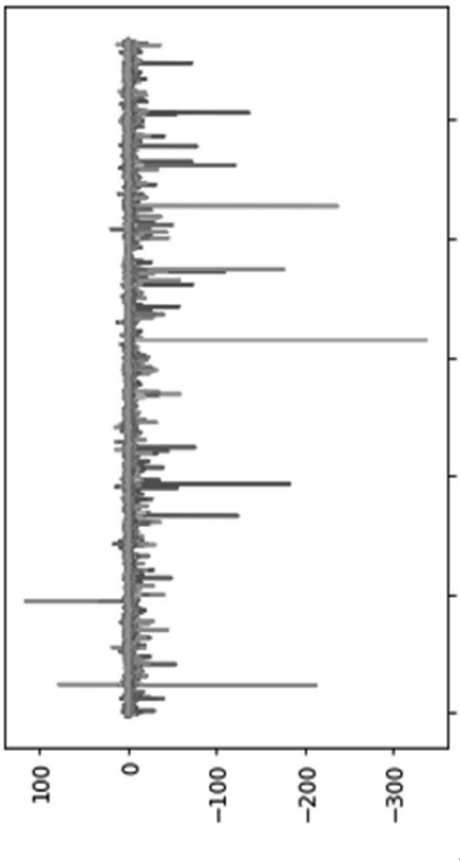


Figure 19



2000

Figure 20A



2002

Figure 20B

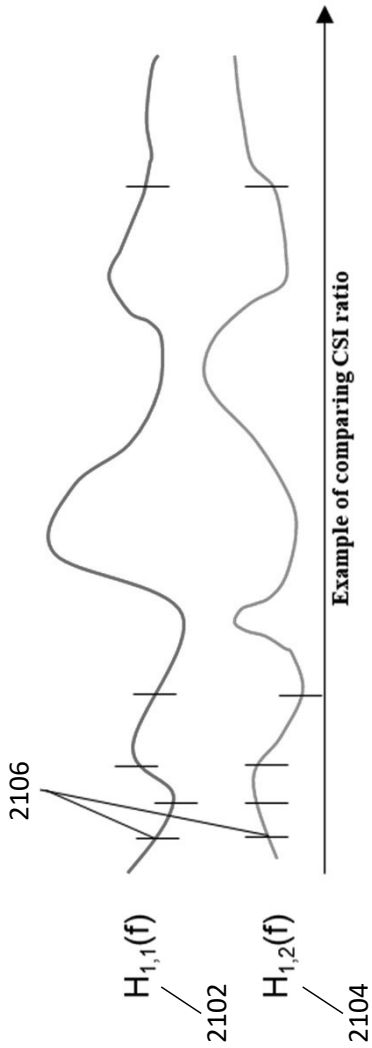
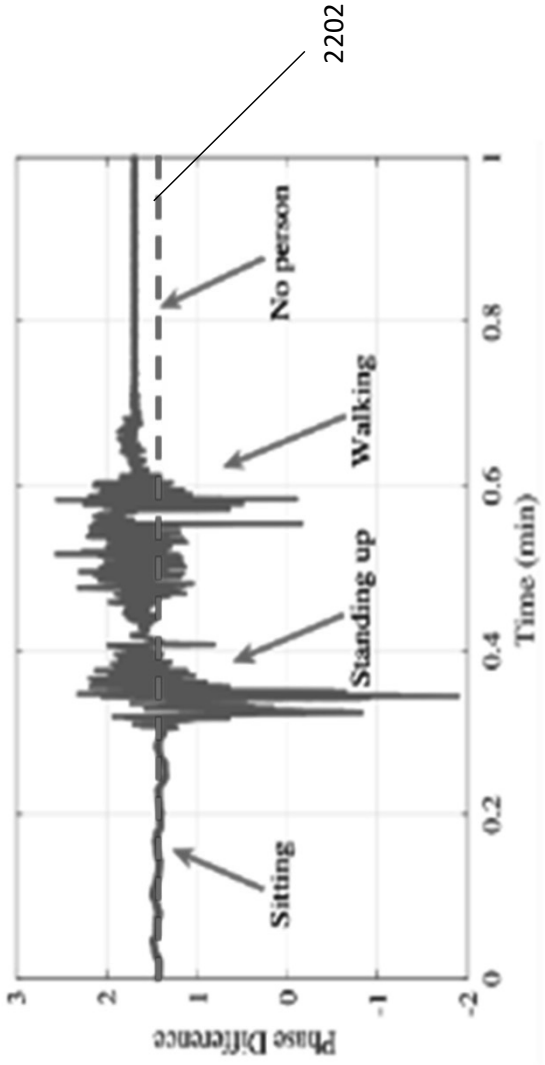

Example of comparing CSI ratio
2106
$H_{1,1}(f)$
2102
$H_{1,2}(f)$
2104
2100

Figure 21



Presence Detection using CSI phase difference

2200

Figure 22

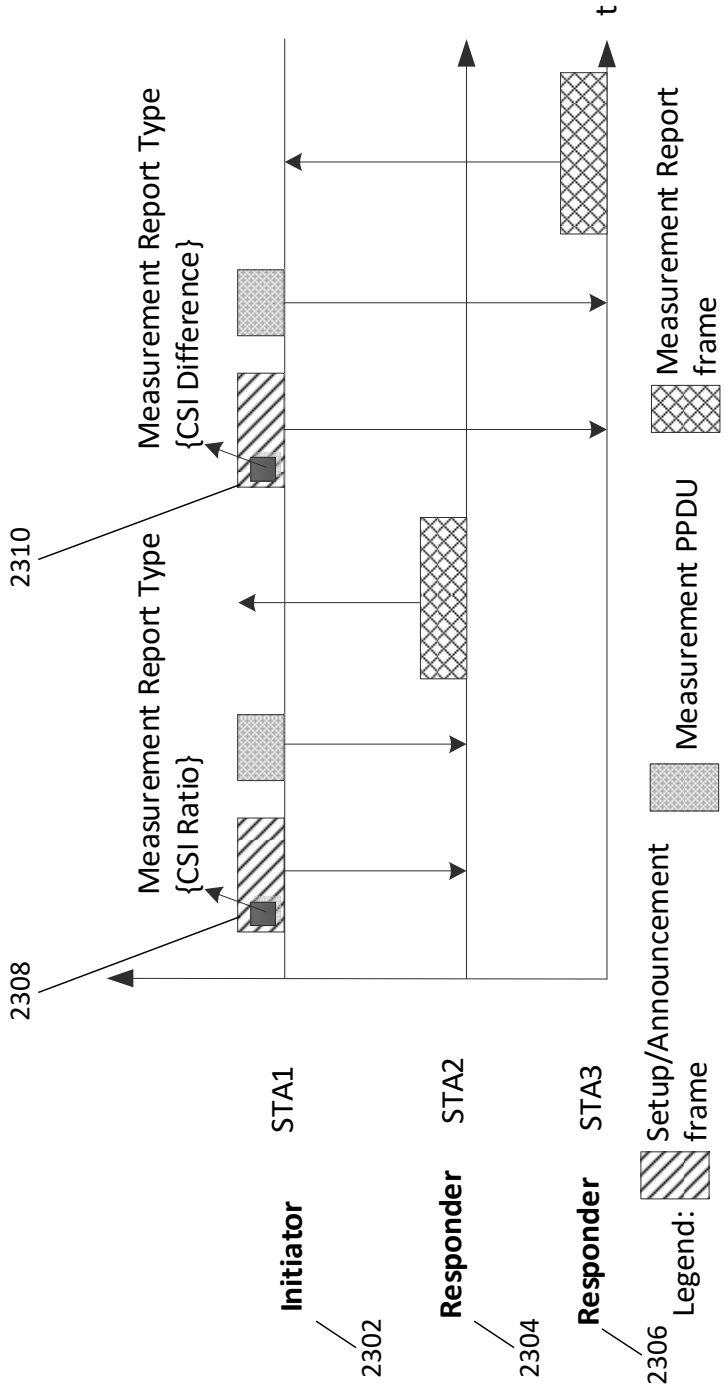

Initiator
STA1
2302
Responder
STA2
2304
Responder
STA3
2306
Legend:
Setup/Announcement frame
Measurement PPDU
Measurement Report frame
t
2308
Measurement Report Type {CSI Ratio}
2310
Measurement Report Type {CSI Difference}
2300

Figure 23

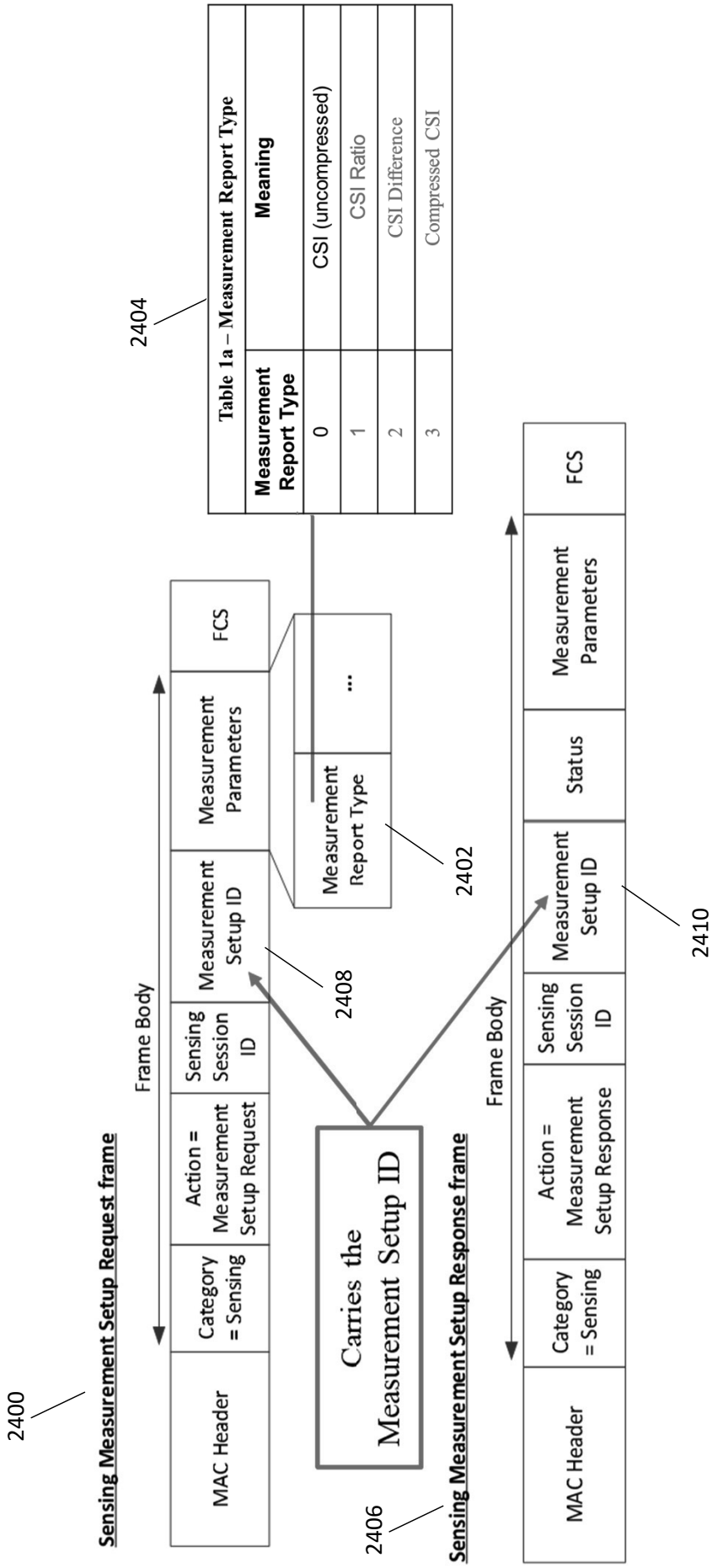

2400
Sensing Measurement Setup Request frame
MAC Header
Category = Sensing
Action = Measurement Setup Request
Sensing Session ID
Measurement Setup ID
Measurement Parameters
FCS
Frame Body
2408
Carries the Measurement Setup ID
2406
Sensing Measurement Setup Response frame
MAC Header
Category = Sensing
Action = Measurement Setup Response
Sensing Session ID
Measurement Setup ID
Status
Measurement Parameters
FCS
Frame Body
2410
Measurement Report Type
...
2402
2404
Table 1a – Measurement Report Type
Measurement Report Type
Meaning
0
CSI (uncompressed)
1
CSI Ratio
2
CSI Difference
3
Compressed CSI

Figure 24

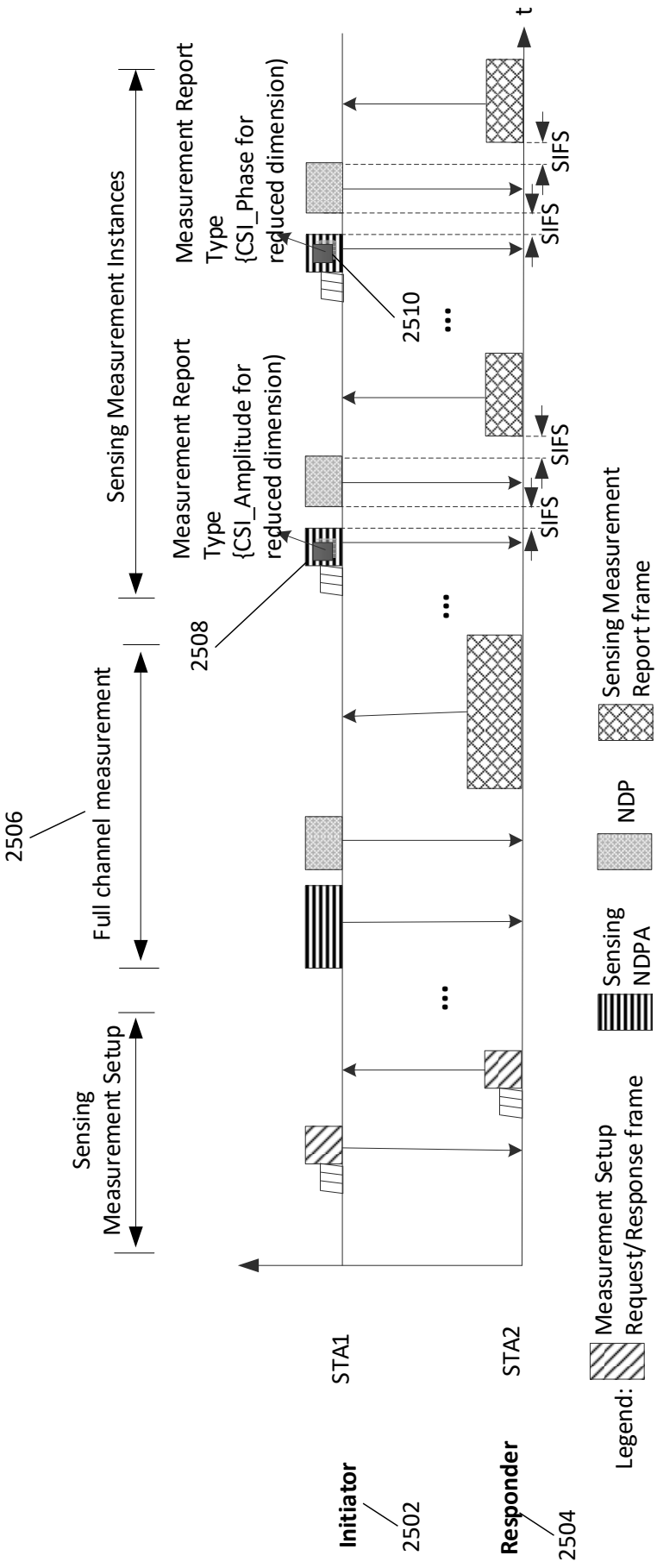

Sensing Measurement Instances
Measurement Report Type {CSI_Phase for reduced dimension)
Measurement Report Type {CSI_Amplitude for reduced dimension)
SIFS
2510
2508
2506
Full channel measurement
Sensing Measurement Setup
t
Sensing Measurement Report frame
NDP
Sensing NDPA
Measurement Setup Request/Response frame
Legend:
STA1
STA2
Initiator
Responder
2502
2504
2500

Figure 25

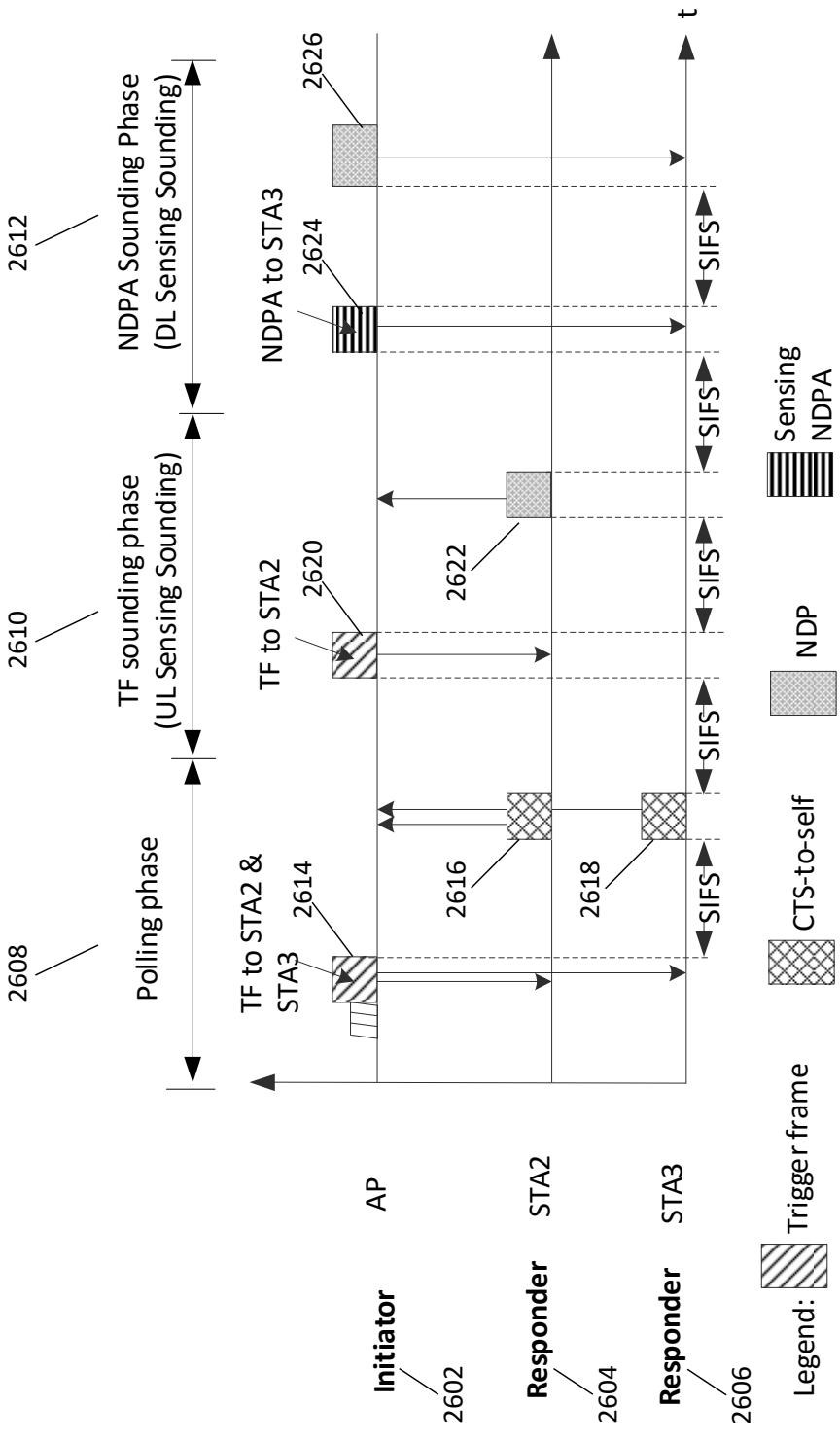

2612
NDPA Sounding Phase
(DL Sensing Sounding)
2610
TF sounding phase
(UL Sensing Sounding)
2608
Polling phase
TF to STA2 &
STA3
2614
TF to STA2
2620
NDPA to STA3
2624
2626
2622
2616
2618
SIFS
t
Sensing
NDPA
NDP
CTS-to-self
Trigger frame
Legend:
Initiator
2602
AP
Responder
2604
STA2
Responder
2606
STA3
2600

Figure 26

Name	Type	Valid range	Description
Responder MAC Address	MACAddress	Any valid MAC Address	The MAC Address of the sensing responder. If response is solicited from multiple responders, this is set to broadcast MAC address.
Member ID List	List of Integers		Indicates a list of IDs (e.g., AIDs) of one ore more STAs from which response is solicited.
Sensing Session ID	Integer	0 - 255	ID of a sensing session
Measurement Setup ID	Integer	0 - 255	ID of a Measurement Setup
Measurement Instance ID	Integer	0 - 255	ID of a Measurement Instance
Number of Streams	Integer	0 - 16	Number of space time streams to be used for the NDP.
Bandwidth	Integer	1 - 16	Indicates the channel bandwidth to be used for the response PPDU in units of 20 MHz.
Measurement Report Type	Enumeration	Reduced dimension CSI feedback(CSI ratio/ CSI difference)	The measurement report type to be passed up to the upper layer upon reception of a NDP.
NDPA Information	Structure		This field carries the information (RA, AID12 etc.) to be included in the NDPA frame during the NDPA Sounding phase.



2700

Figure 27

Name	Type	Valid range	Description
MAC Address	MACAddress	Any valid MAC Address	The MAC Address of the STA from which the NDP is received.
Member ID	List of Integers		Indicates the IDs (e.g., AIDs) of the STAs from which the NDP is received.
Sensing Session ID	Integer	0 - 255	ID of a sensing session
Measurement Setup ID	Integer	0 - 255	ID of a measurement
Measurement Instance ID	Integer	0 - 255	ID of a Measurement Instance
Bandwidth	Integer	1 - 16	Indicates the channel bandwidth of the NDP in units of 20 MHz.
Measurement Report Type	Enumeration	Reduced dimension CSI feedback(CSI Ratio/CSI Difference)	Indicates the format of the FeedbackMatrix.
NumberOfSubcarriers_Ns	Integer	1 - 1023	Number of subcarriers for which channel measurements are reported
NumberOfColumns_Nc	Integer	1 - 16	Number of columns in the reported FeedbackMatrix
NumberOfReceiveChains_Nr	Integer	1 - 16	Number of rows in the reported FeedbackMatrix
NumberOfBitsPerElement_Nb	Integer	1 - 16	Number of bits used for each complex element of the FeedbackMatrix
FeedbackMatrix	Matrix		When the Measurement Report Type indicates CSI_Amplitude or CSI_Phase, the format of the FeedbackMatrix is the same as shown in any of the Table 2a, Table 3, Table 3a or Table 4. For CSI, CSI_I and CSI_Q, similar format as defined in [1] may be used, except that for CSI_I and CSI_Q, only the indicated sub-component is present instead of both I and Q.
SNRList	List		List of Signal-to-noise ratio (SNR) in the Nr receiver chains (8bits per chain).

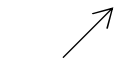


Figure 28

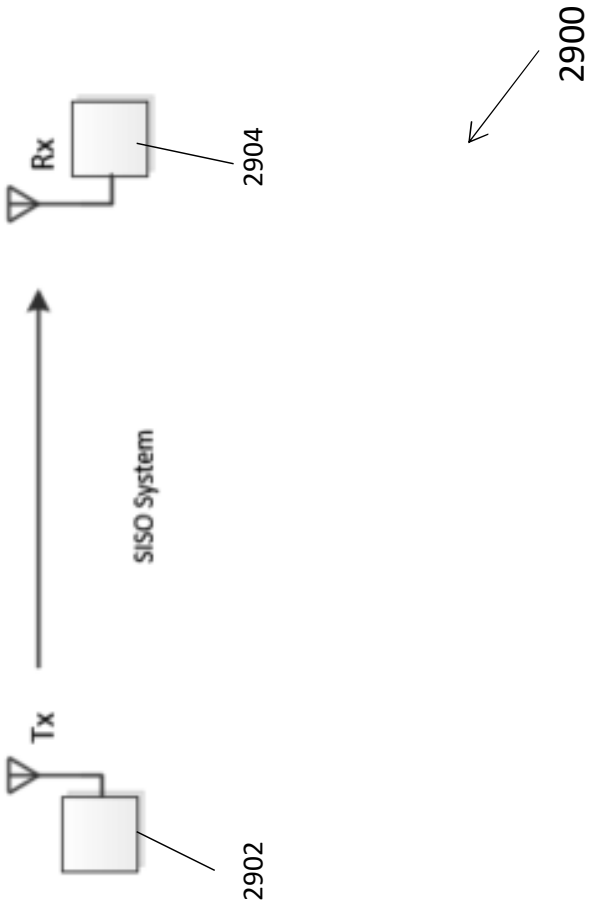


Figure 29

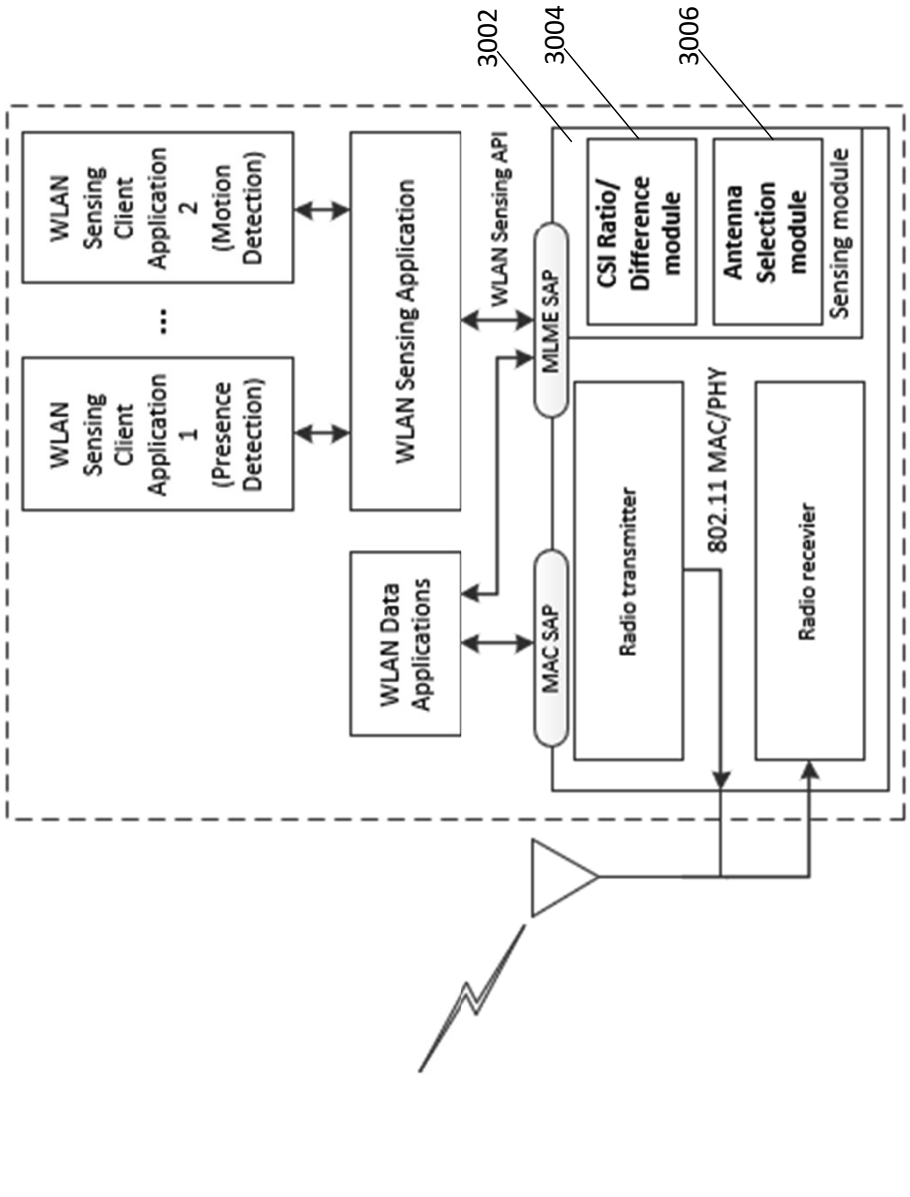

3002
3004
3006
WLAN Sensing Client Application 2 (Motion Detection)
...
WLAN Sensing Client Application 1 (Presence Detection)
WLAN Sensing Application
WLAN Sensing API
MLME SAP
CSI Ratio/ Difference module
Antenna Selection module
Sensing module
WLAN Data Applications
MAC SAP
Radio transmitter
802.11 MAC/PHY
Radio recevier
3000

Figure 30

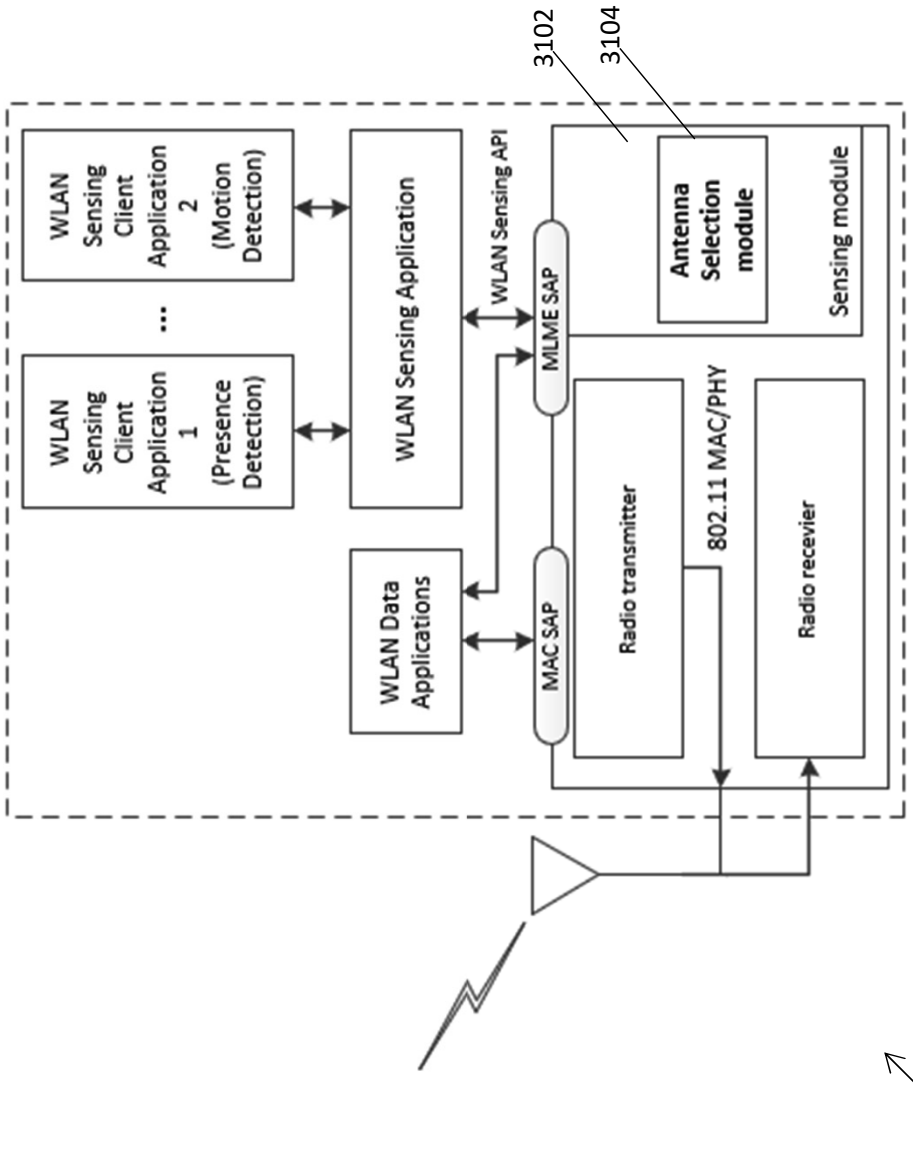

3102
3104
WLAN Sensing Client Application 2 (Motion Detection)
...
WLAN Sensing Client Application 1 (Presence Detection)
WLAN Sensing Application
WLAN Sensing API
MLME SAP
Antenna Selection module
Sensing module
WLAN Data Applications
MAC SAP
Radio transmitter
802.11 MAC/PHY
Radio recevier
3100

Figure 31

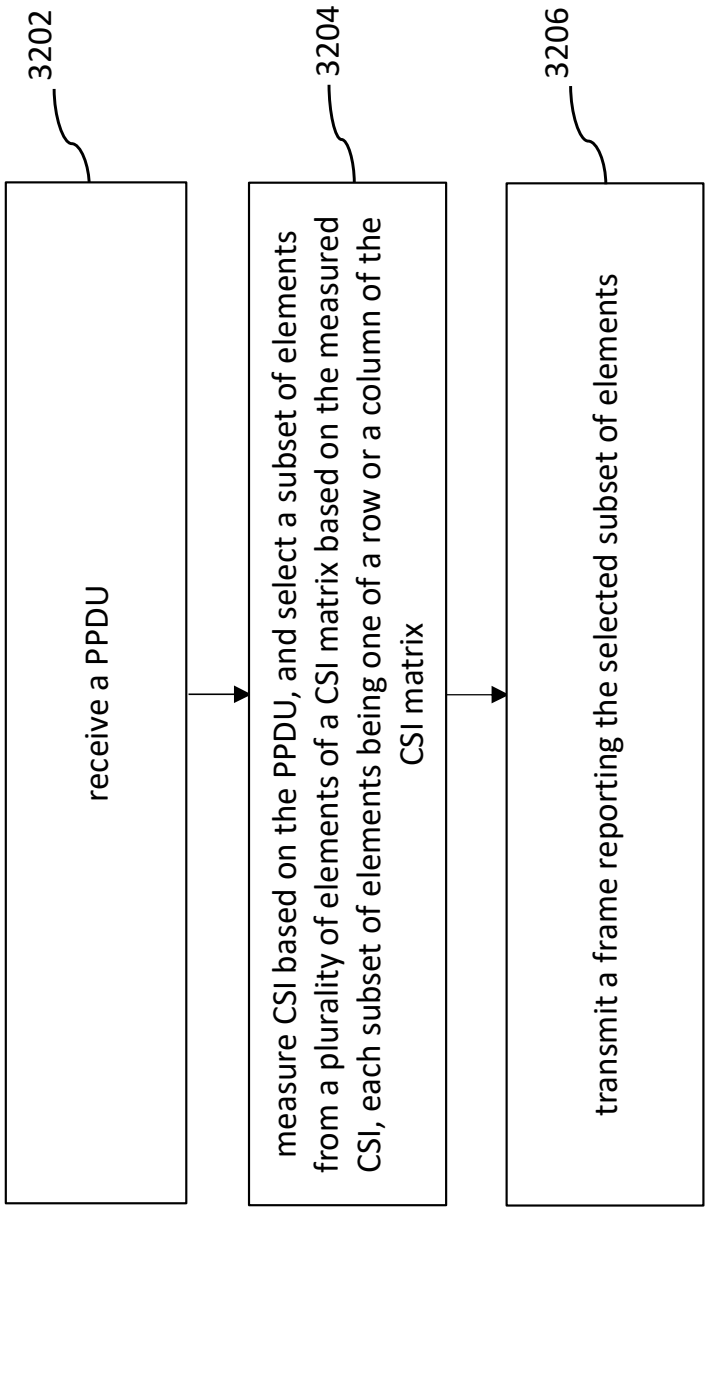

3202
receive a PPDU
3204
measure CSI based on the PPDU, and select a subset of elements from a plurality of elements of a CSI matrix based on the measured CSI, each subset of elements being one of a row or a column of the CSI matrix
3206
transmit a frame reporting the selected subset of elements
3200

Figure 32

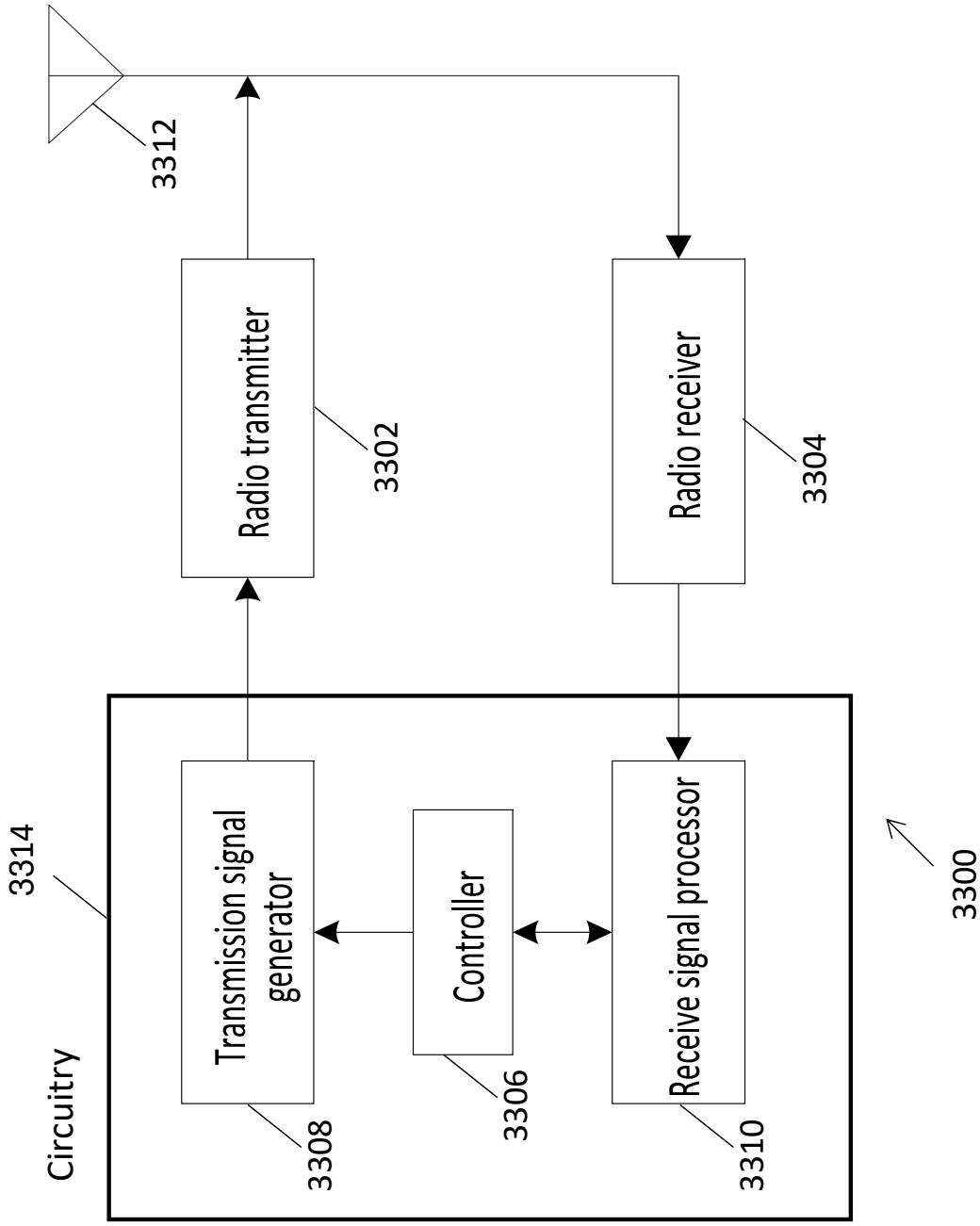

3312
Radio transmitter
3302
Radio receiver
3304
3314
Circuitry
Transmission signal generator
3308
Controller
3306
Receive signal processor
3310
3300

Figure 33