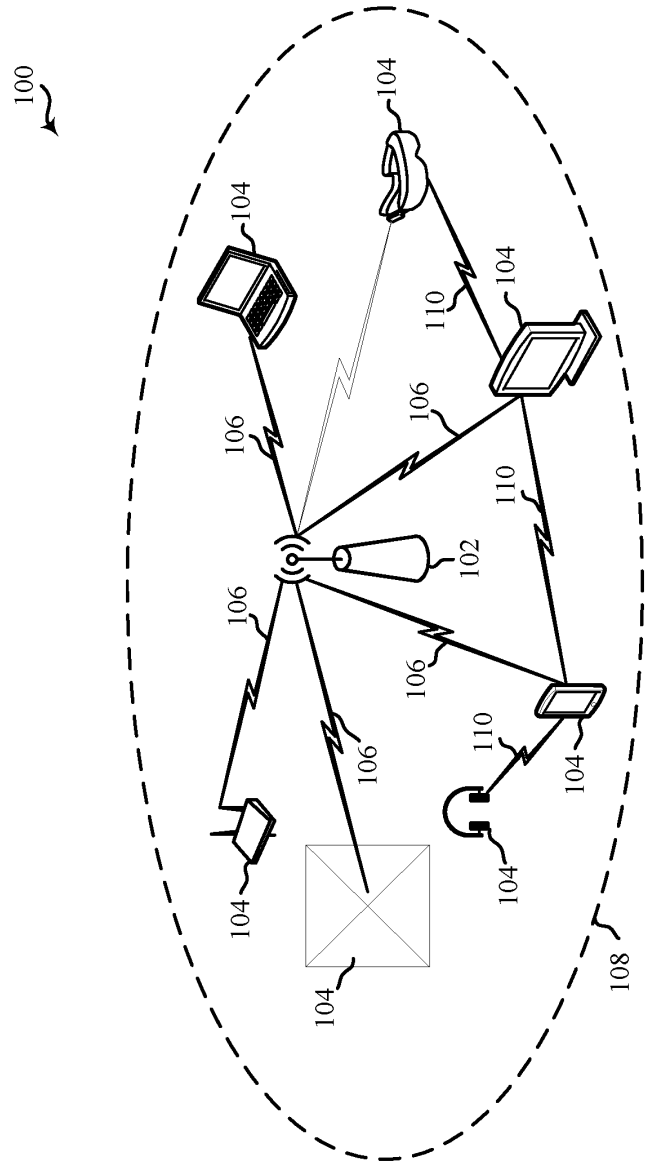
100
104
104
104
110
106
106
110
102
106
106
110
104
104
104
104
108

Figure 1

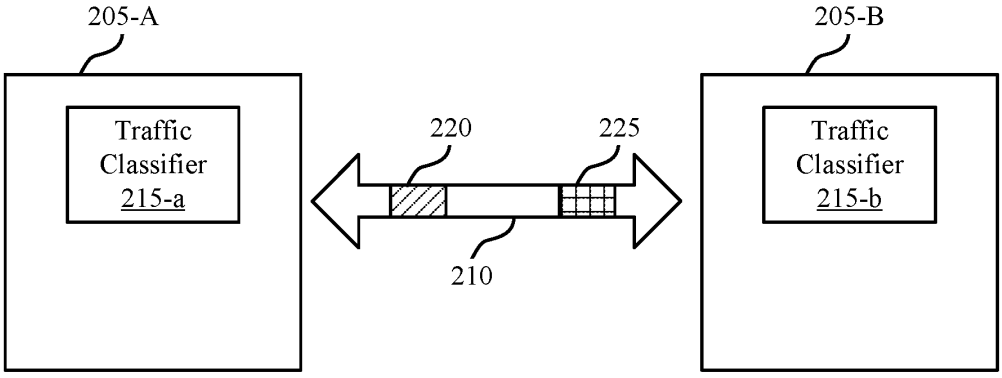
205-A
205-B
Traffic Classifier 215-a
Traffic Classifier 215-b
220
225
210
200

Figure 2

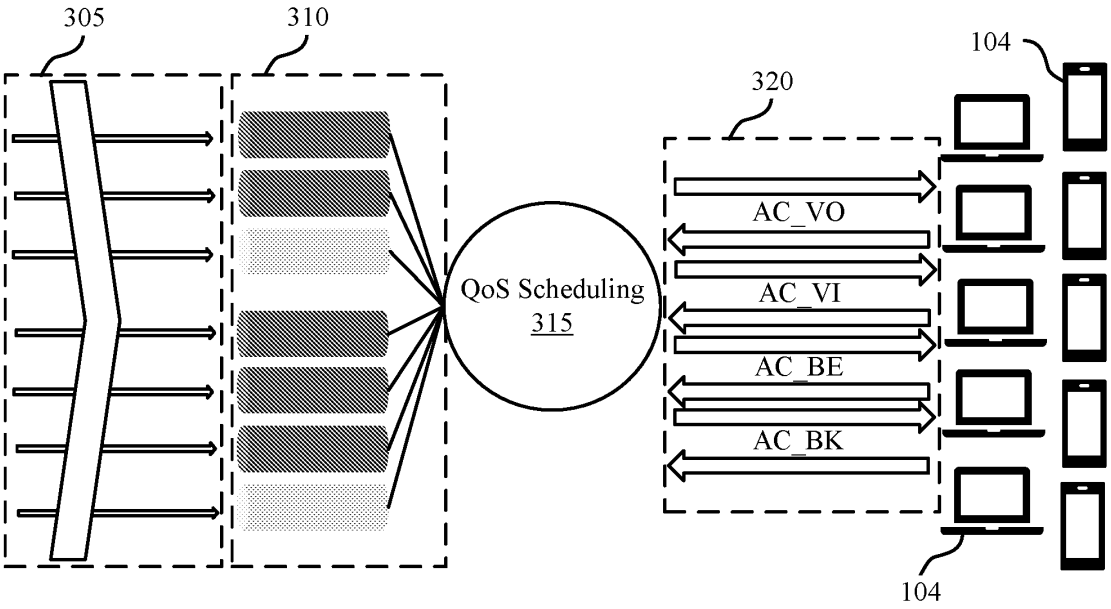
305
310
104
320
AC_VO
QoS Scheduling
315
AC_VI
AC_BE
AC_BK
104
300

Figure 3

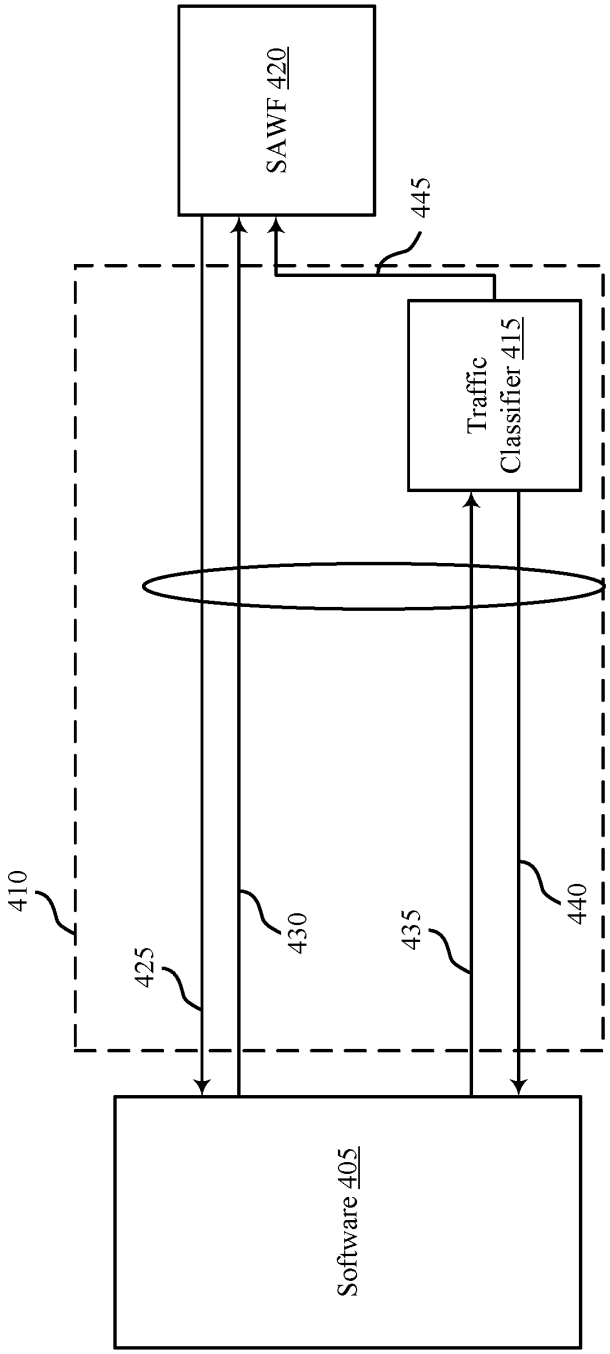
SAWF 420
445
400
Traffic Classifier 415
410
425
430
435
440
Software 405

Figure 4

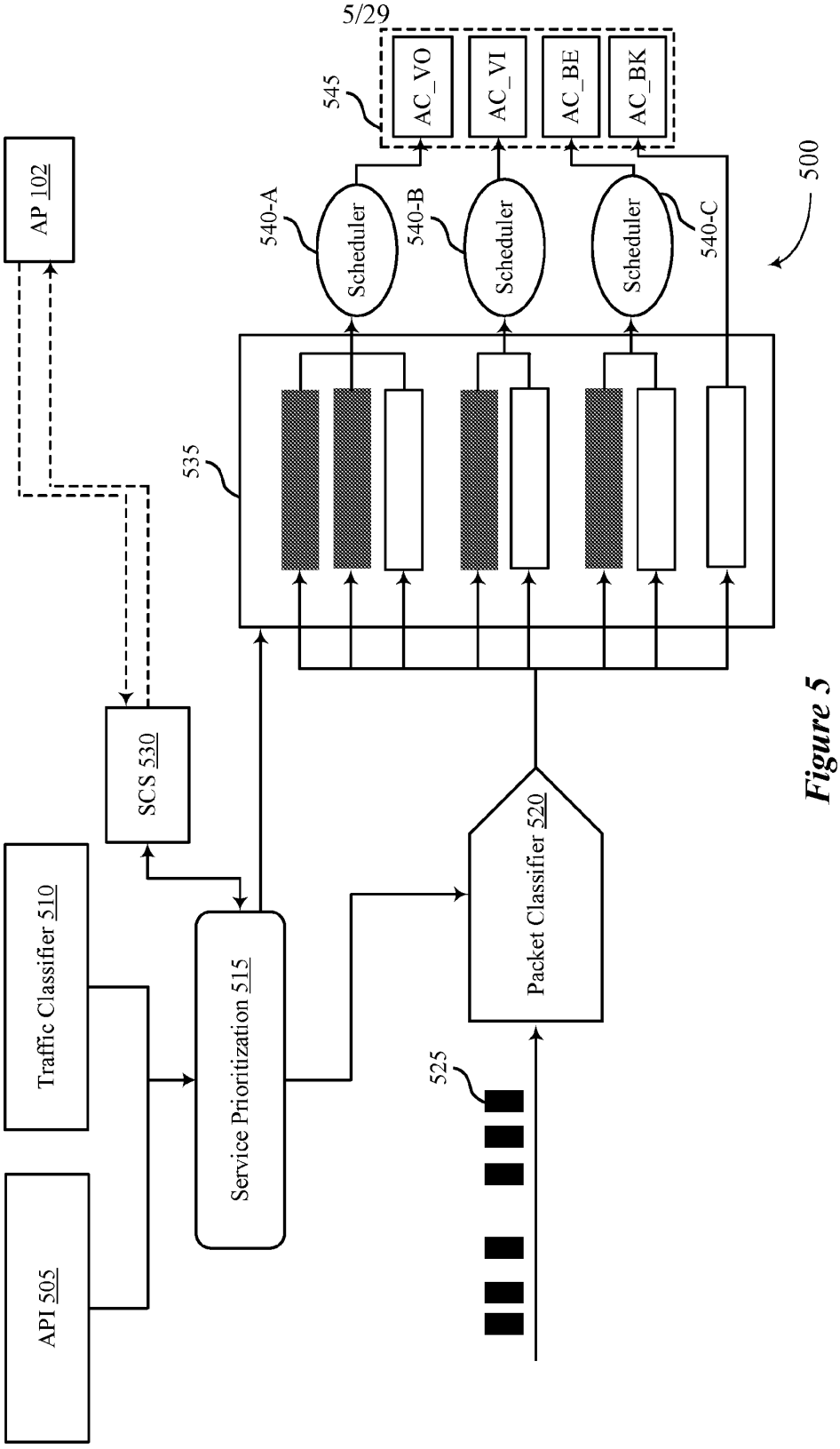
AP 102
SCS 530
Traffic Classifier 510
API 505
Service Prioritization 515
Packet Classifier 520
525
535
545
AC_VO
AC_VI
AC_BE
AC_BK
540-A
Scheduler
540-B
Scheduler
Scheduler
540-C
500

Figure 5

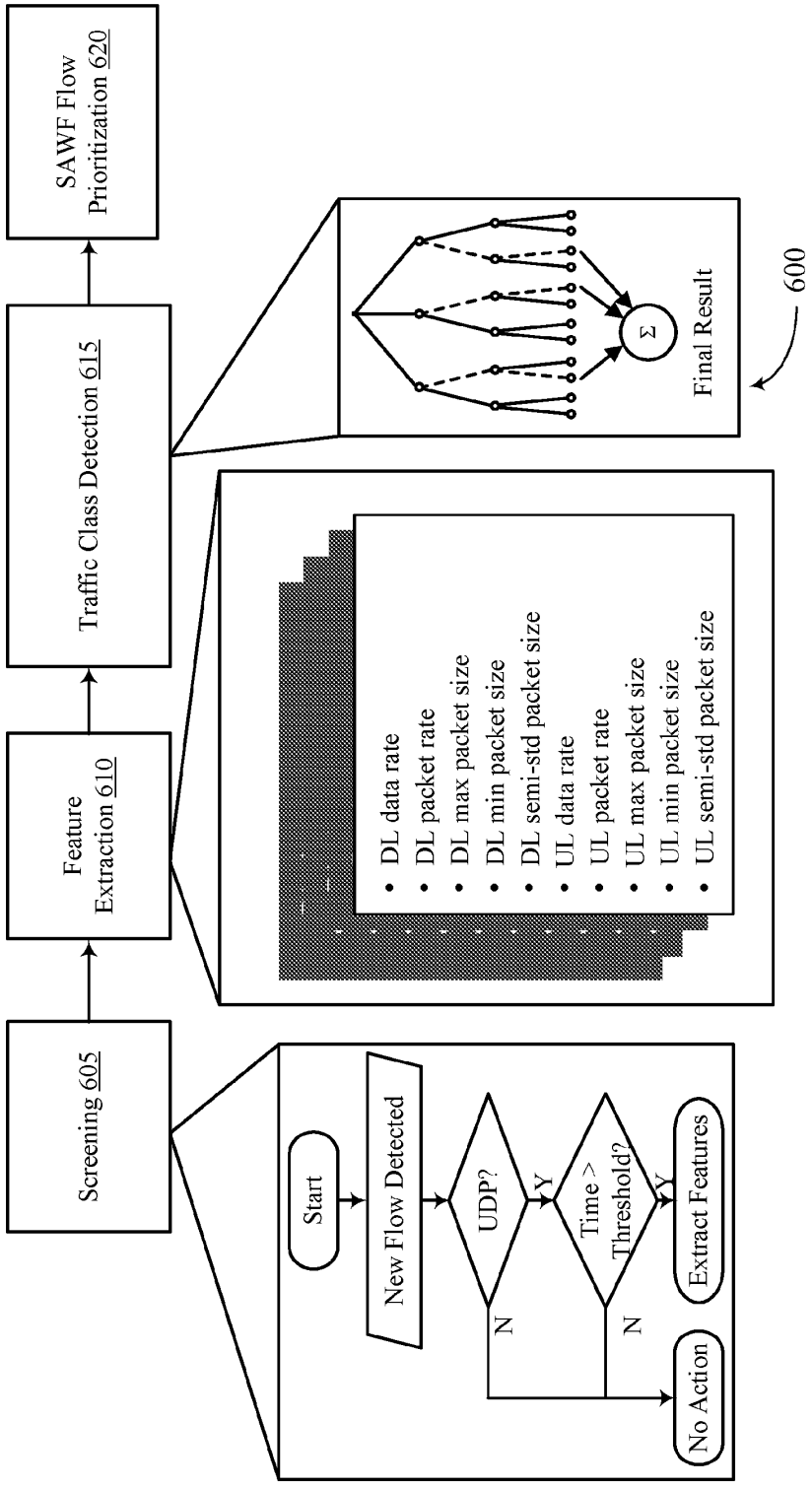
Screening 605
Feature Extraction 610
Traffic Class Detection 615
SAWF Flow Prioritization 620
Start
New Flow Detected
UDP?
Y
N
Time > Threshold?
Y
N
No Action
Extract Features
DL data rate
DL packet rate
DL max packet size
DL min packet size
DL semi-std packet size
UL data rate
UL packet rate
UL max packet size
UL min packet size
UL semi-std packet size
Σ
Final Result
600

Figure 6

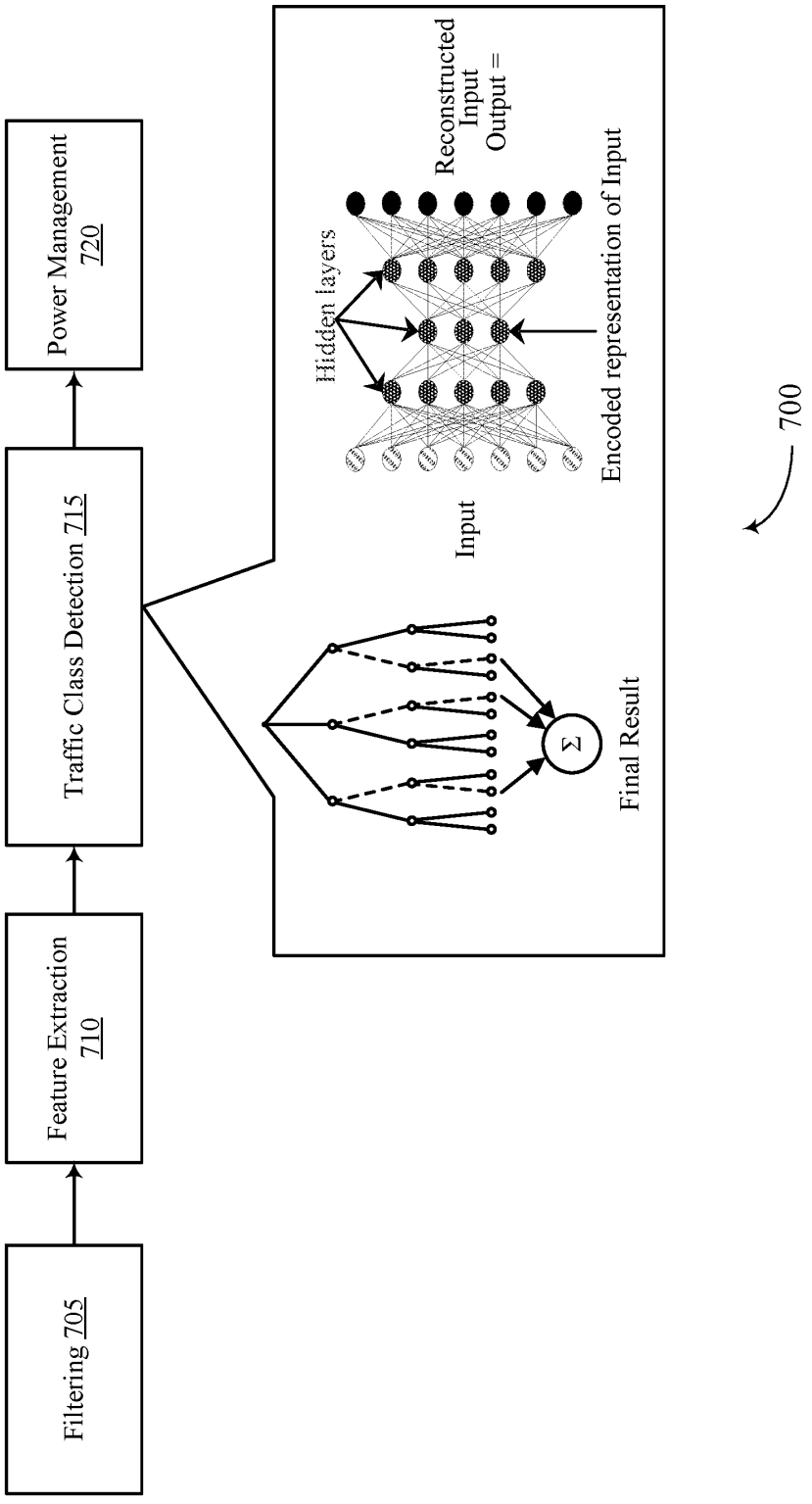
Filtering 705
Feature Extraction 710
Traffic Class Detection 715
Power Management 720
Input
Hidden layers
Reconstructed Input
Output =
Encoded representation of Input
Σ
Final Result
700

Figure 7

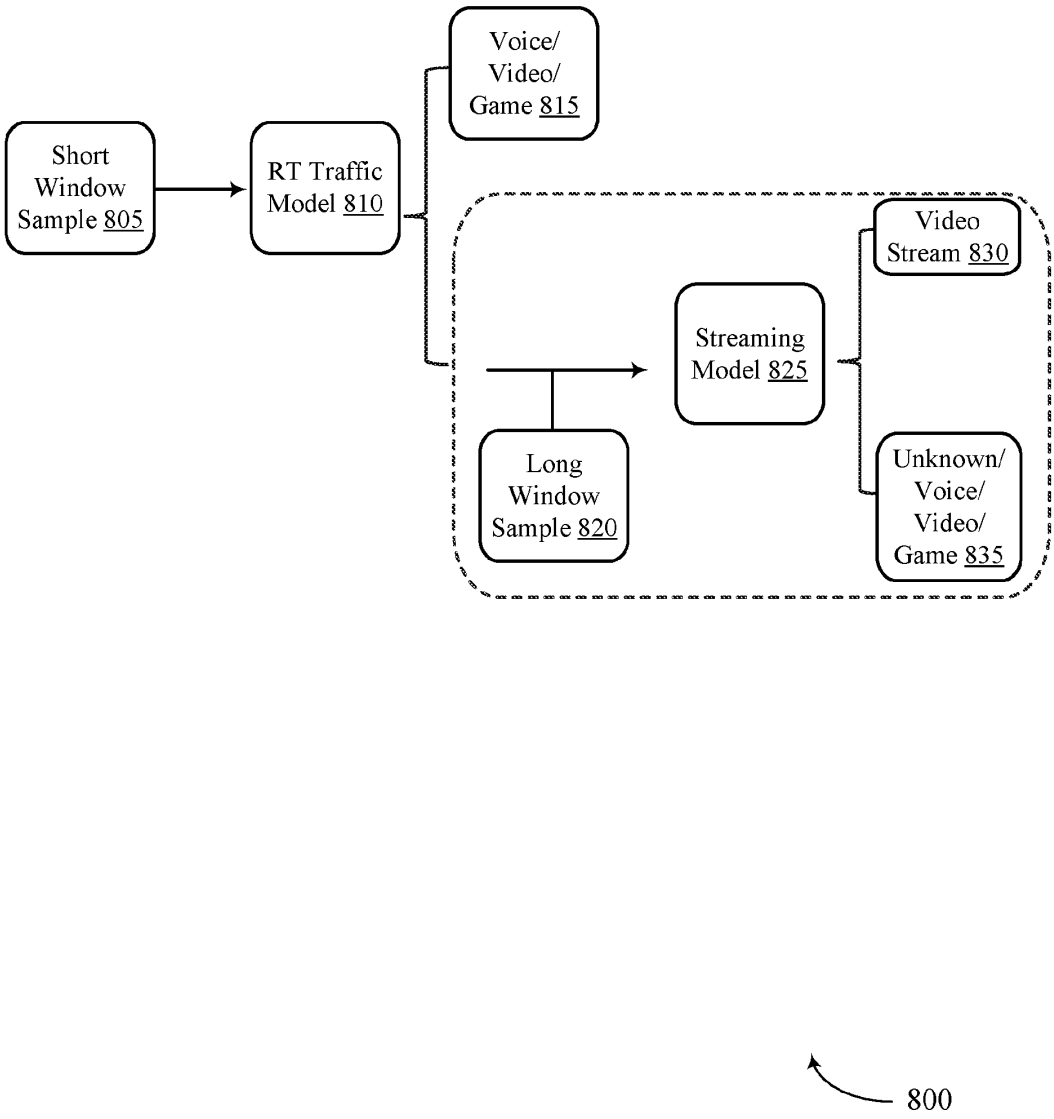
Short Window Sample 805
RT Traffic Model 810
Voice/ Video/ Game 815
Streaming Model 825
Video Stream 830
Long Window Sample 820
Unknown/ Voice/ Video/ Game 835
800

Figure 8

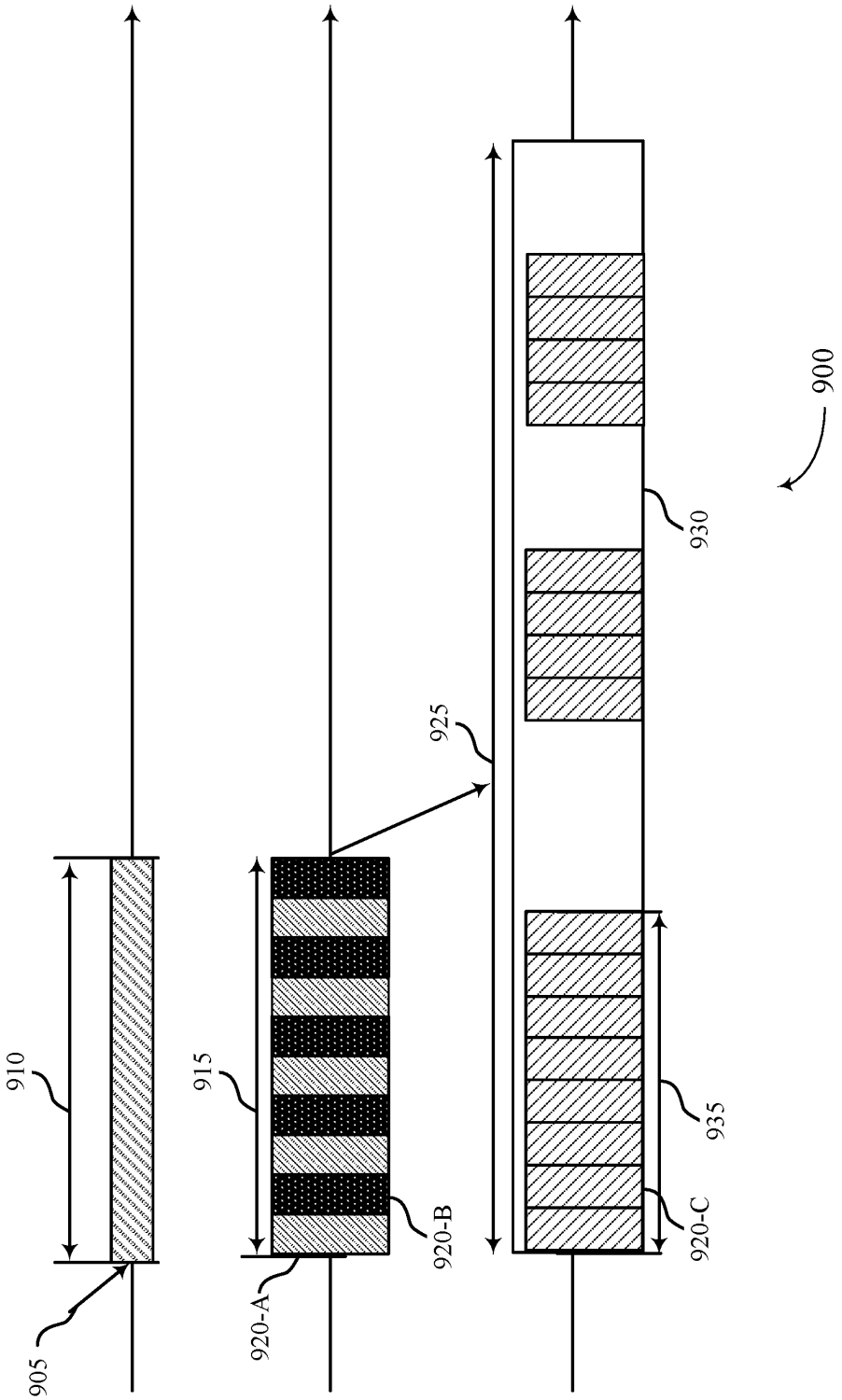

Figure 9

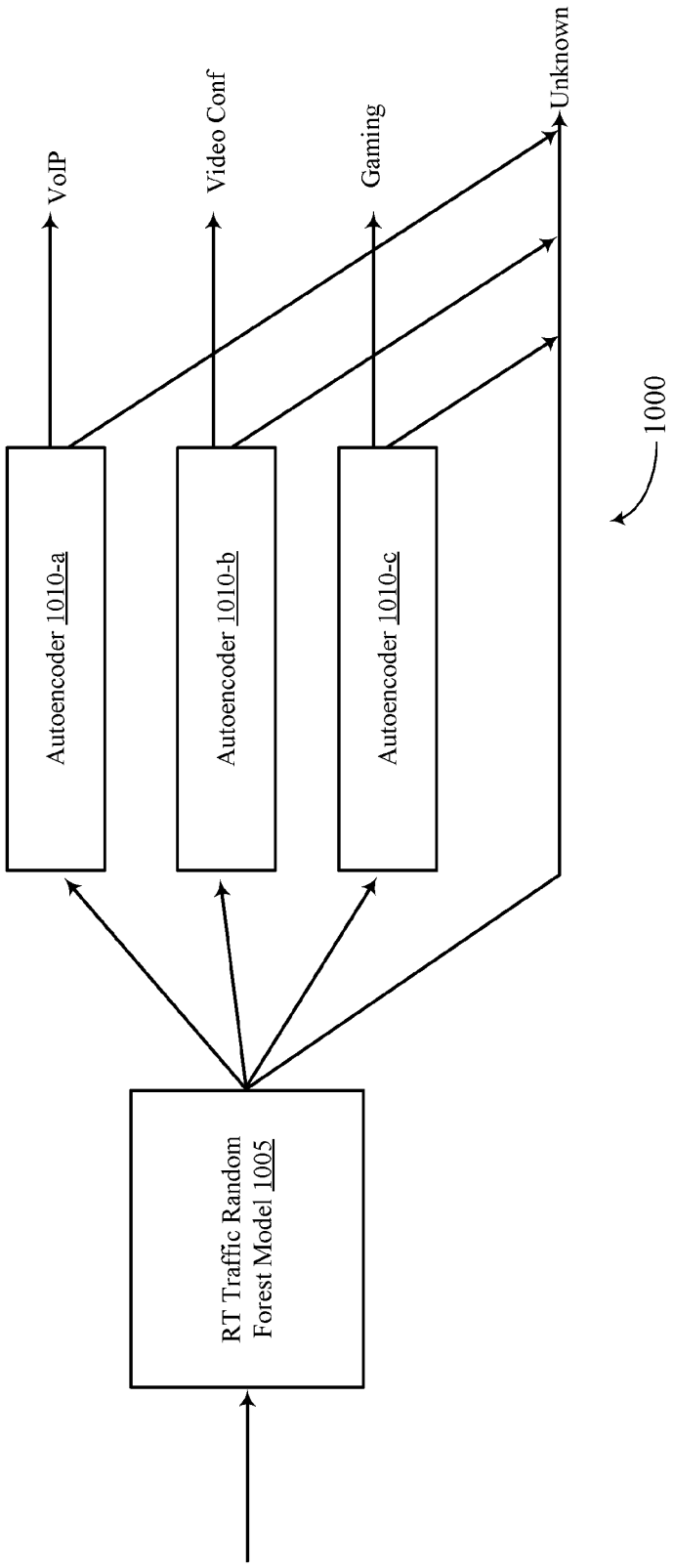
RT Traffic Random Forest Model 1005
Autoencoder 1010-a
Autoencoder 1010-b
Autoencoder 1010-c
VoIP
Video Conf
Gaming
Unknown
1000

Figure 10

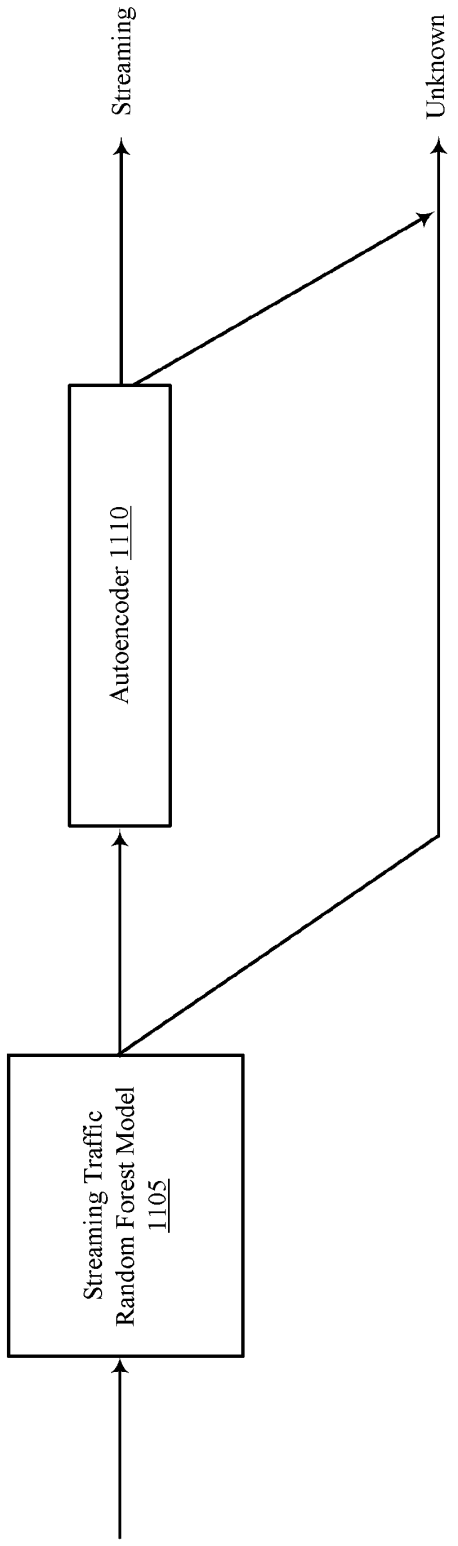
Streaming
Unknown
Autoencoder 1110
Streaming Traffic
Random Forest Model
1105
1100

Figure 11

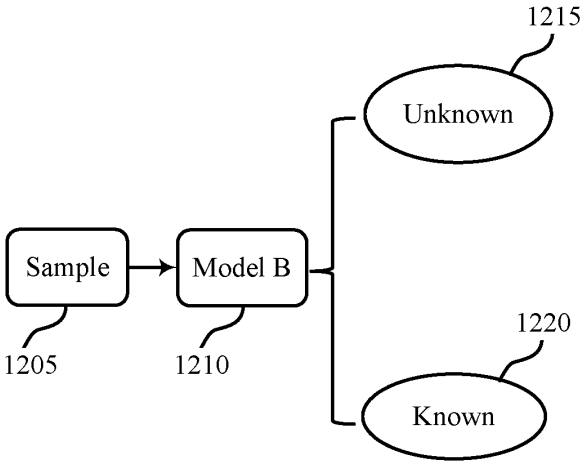

Figure 12A

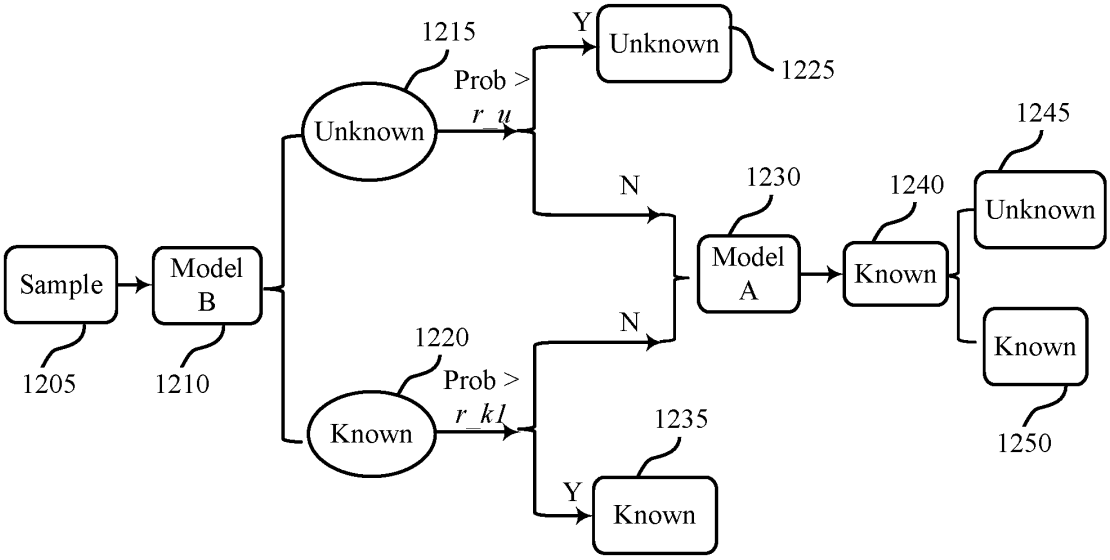

Figure 12B

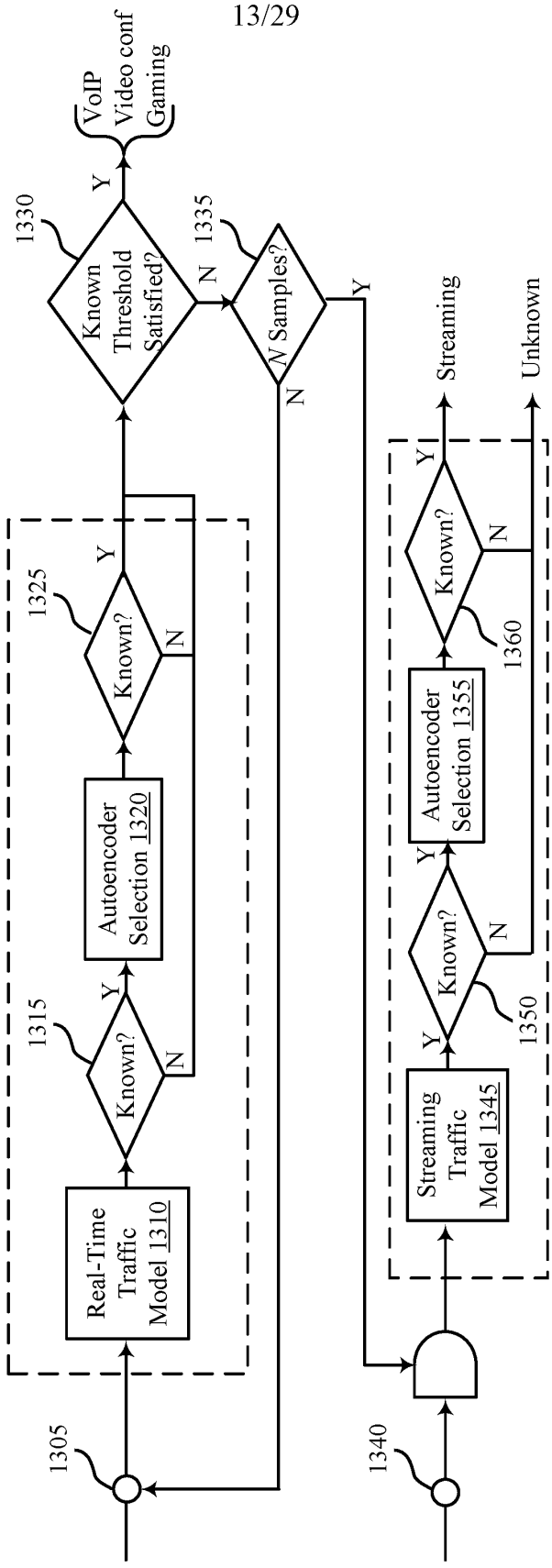
1300
1305
1310
Real-Time Traffic Model
1315
Known?
Y
N
1320
Autoencoder Selection
1325
Known?
Y
N
1330
Known Threshold Satisfied?
Y
N
VoIP
Video conf
Gaming
1335
N Samples?
N
Y
1340
1345
Streaming Traffic Model
1350
Known?
Y
N
1355
Autoencoder Selection
1360
Known?
Y
N
Streaming
Unknown

Figure 13

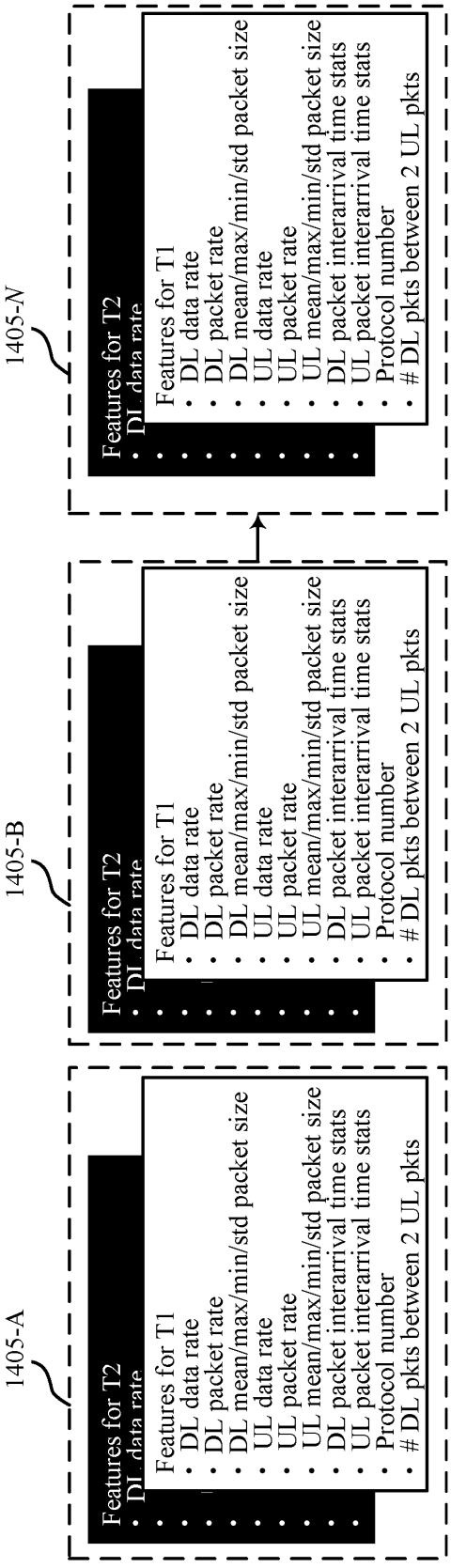
1405-A
Features for T2
• DL data rate
Features for T1
• DL data rate
• DL packet rate
• DL mean/max/min/std packet size
• UL data rate
• UL packet rate
• UL mean/max/min/std packet size
• DL packet interarrival time stats
• UL packet interarrival time stats
• Protocol number
• # DL pkts between 2 UL pkts
1405-B
Features for T2
• DL data rate
Features for T1
• DL data rate
• DL packet rate
• DL mean/max/min/std packet size
• UL data rate
• UL packet rate
• UL mean/max/min/std packet size
• DL packet interarrival time stats
• UL packet interarrival time stats
• Protocol number
• # DL pkts between 2 UL pkts
1405-N
Features for T2
• DL data rate
Features for T1
• DL data rate
• DL packet rate
• DL mean/max/min/std packet size
• UL data rate
• UL packet rate
• UL mean/max/min/std packet size
• DL packet interarrival time stats
• UL packet interarrival time stats
• Protocol number
• # DL pkts between 2 UL pkts
1400

Figure 14

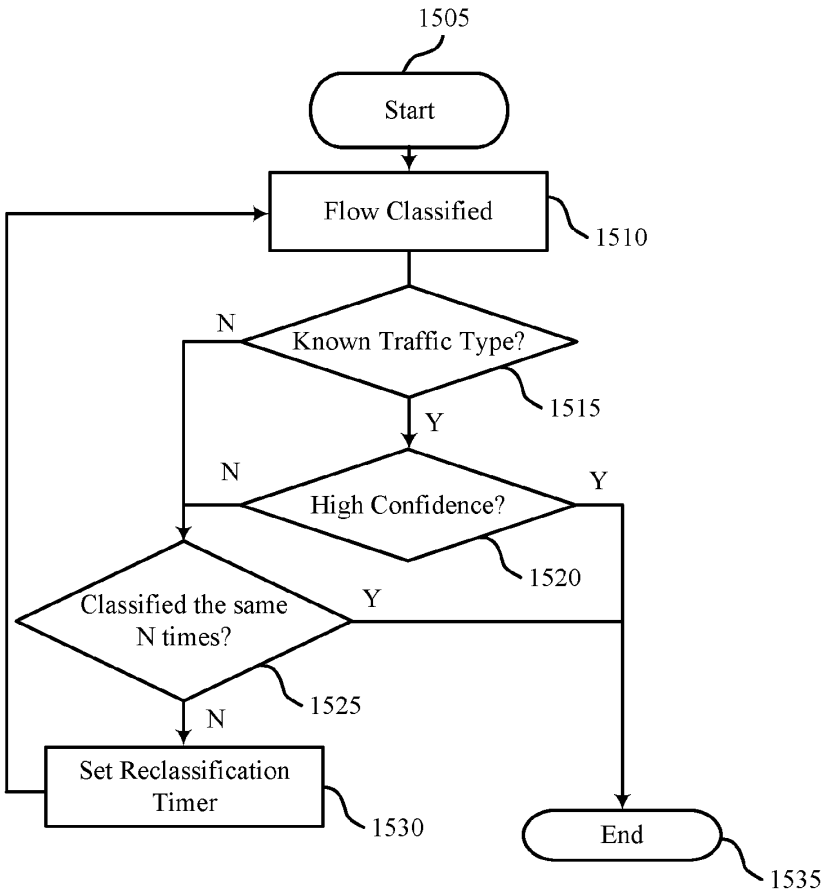
1505
Start
Flow Classified
1510
N
Known Traffic Type?
1515
Y
N
High Confidence?
Y
1520
Classified the same N times?
Y
1525
N
Set Reclassification Timer
1530
End
1535
1500

Figure 15

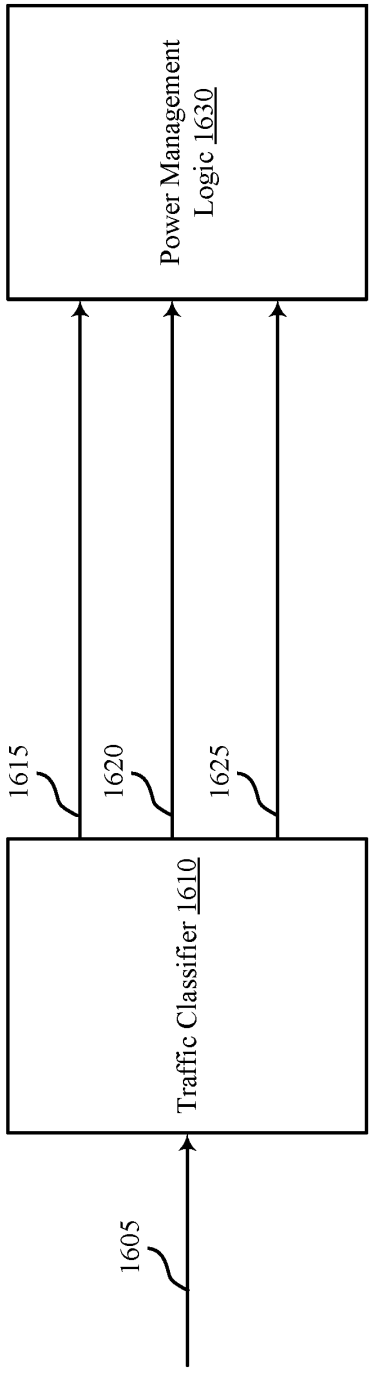
Power Management Logic 1630
1600
1615
1620
1625
Traffic Classifier 1610
1605

Figure 16

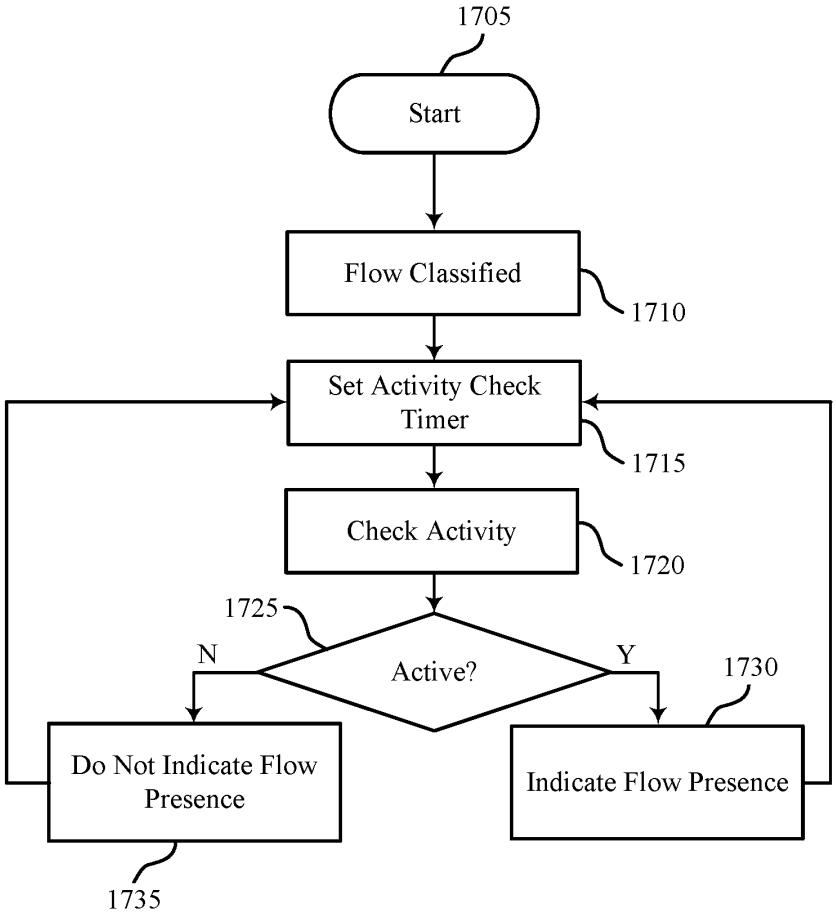
1705
Start
Flow Classified
1710
Set Activity Check Timer
1715
Check Activity
1720
1725
N
Active?
Y
1730
Do Not Indicate Flow Presence
Indicate Flow Presence
1735
1700

Figure 17

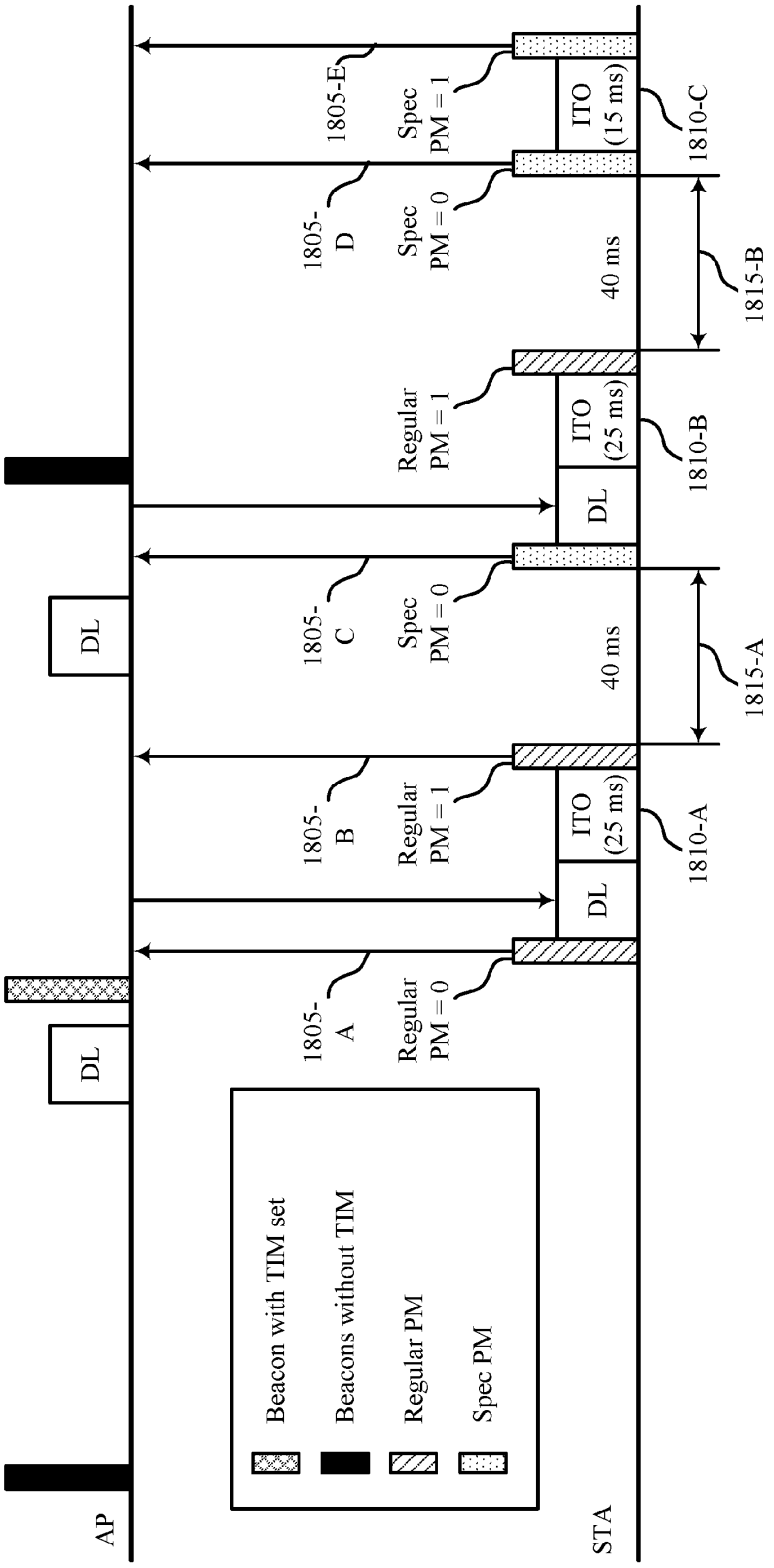
AP
STA
Beacon with TIM set
Beacons without TIM
Regular PM
Spec PM
DL
DL
1805-A
Regular PM = 0
1805-B
Regular PM = 1
1805-C
Spec PM = 0
1805-D
Spec PM = 0
1805-E
Spec PM = 1
DL
ITO (25 ms)
1810-A
DL
ITO (25 ms)
1810-B
ITO (15 ms)
1810-C
40 ms
1815-A
40 ms
1815-B
1800

Figure 18

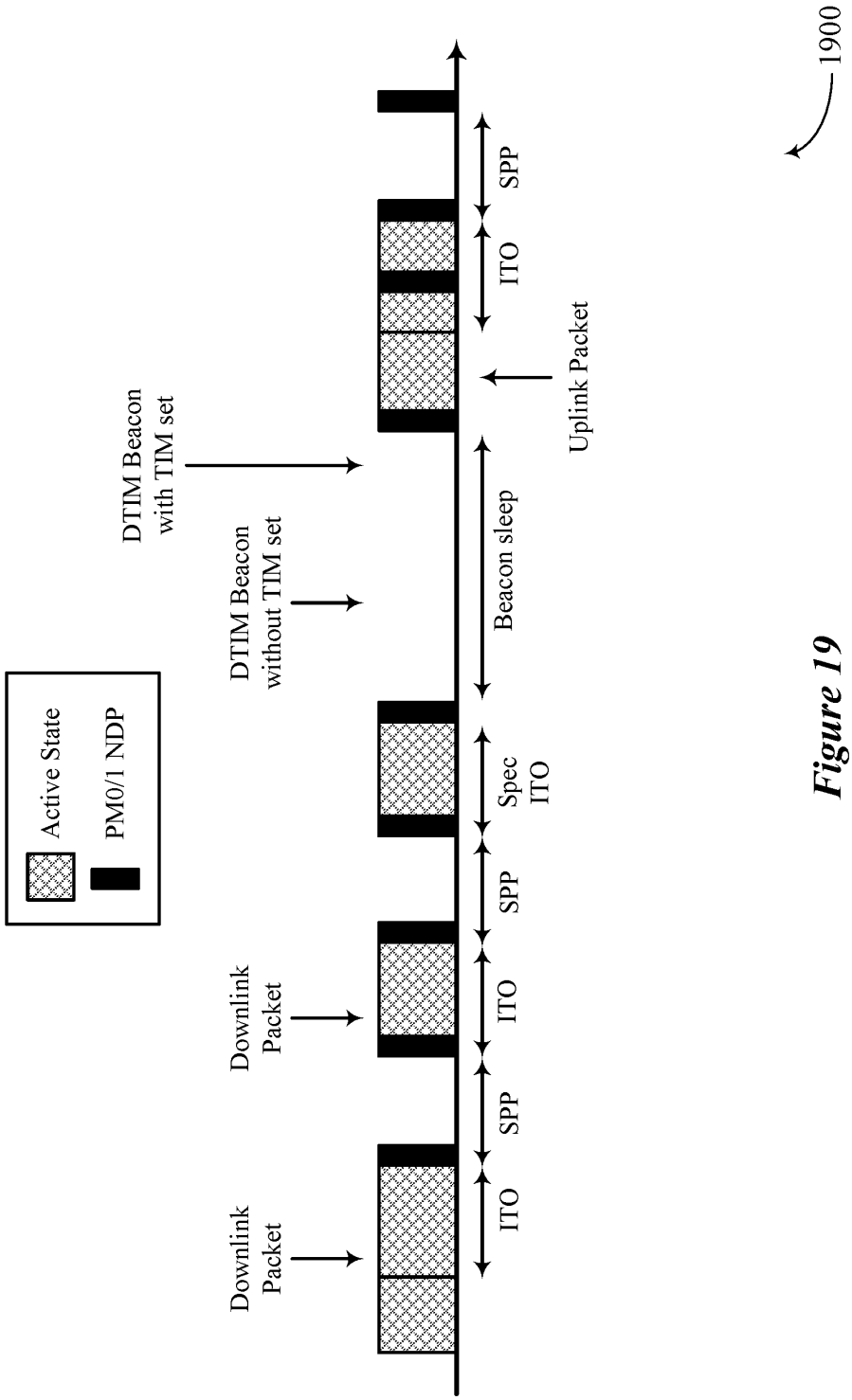
1900
Active State
PM0/1 NDP
DTIM Beacon with TIM set
DTIM Beacon without TIM set
Downlink Packet
Downlink Packet
ITO
SPP
ITO
SPP
Spec ITO
Beacon sleep
Uplink Packet
ITO
SPP

Figure 19

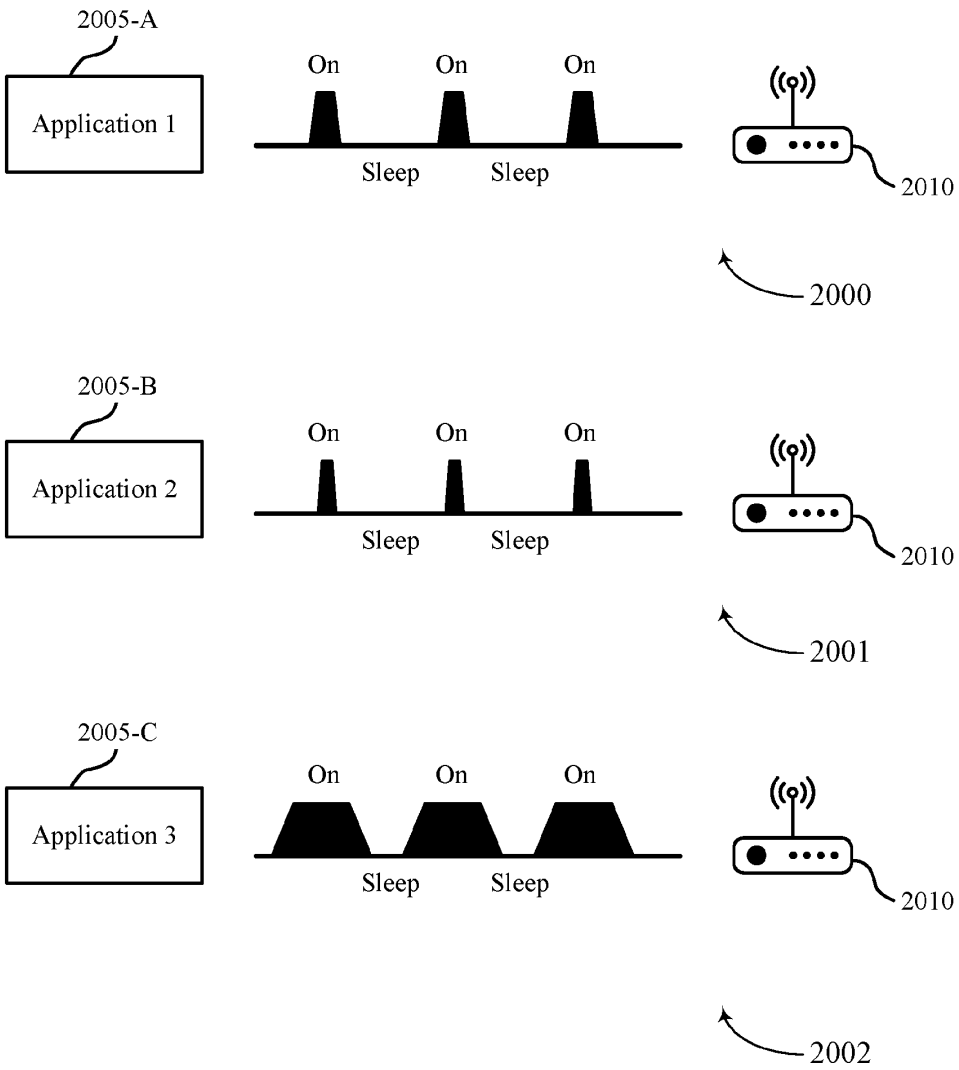
2005-A
Application 1
On
On
On
Sleep
Sleep
2010
2000
2005-B
Application 2
On
On
On
Sleep
Sleep
2010
2001
2005-C
Application 3
On
On
On
Sleep
Sleep
2010
2002

Figure 20

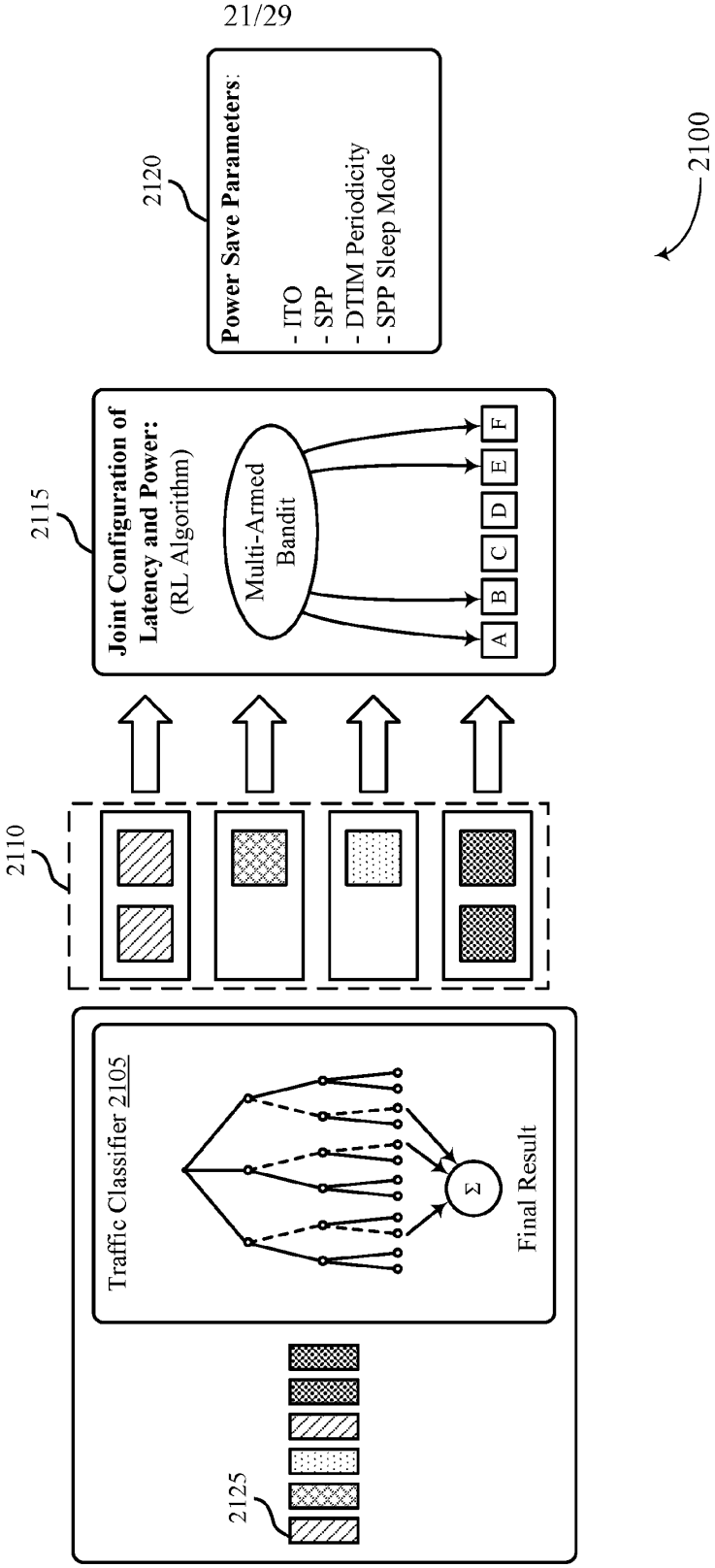
2100
2120
Power Save Parameters:
- ITO
- SPP
- DTIM Periodicity
- SPP Sleep Mode
2115
Joint Configuration of Latency and Power:
(RL Algorithm)
Multi-Armed Bandit
A
B
C
D
E
F
2110
Traffic Classifier 2105
Σ
Final Result
2125

Figure 21

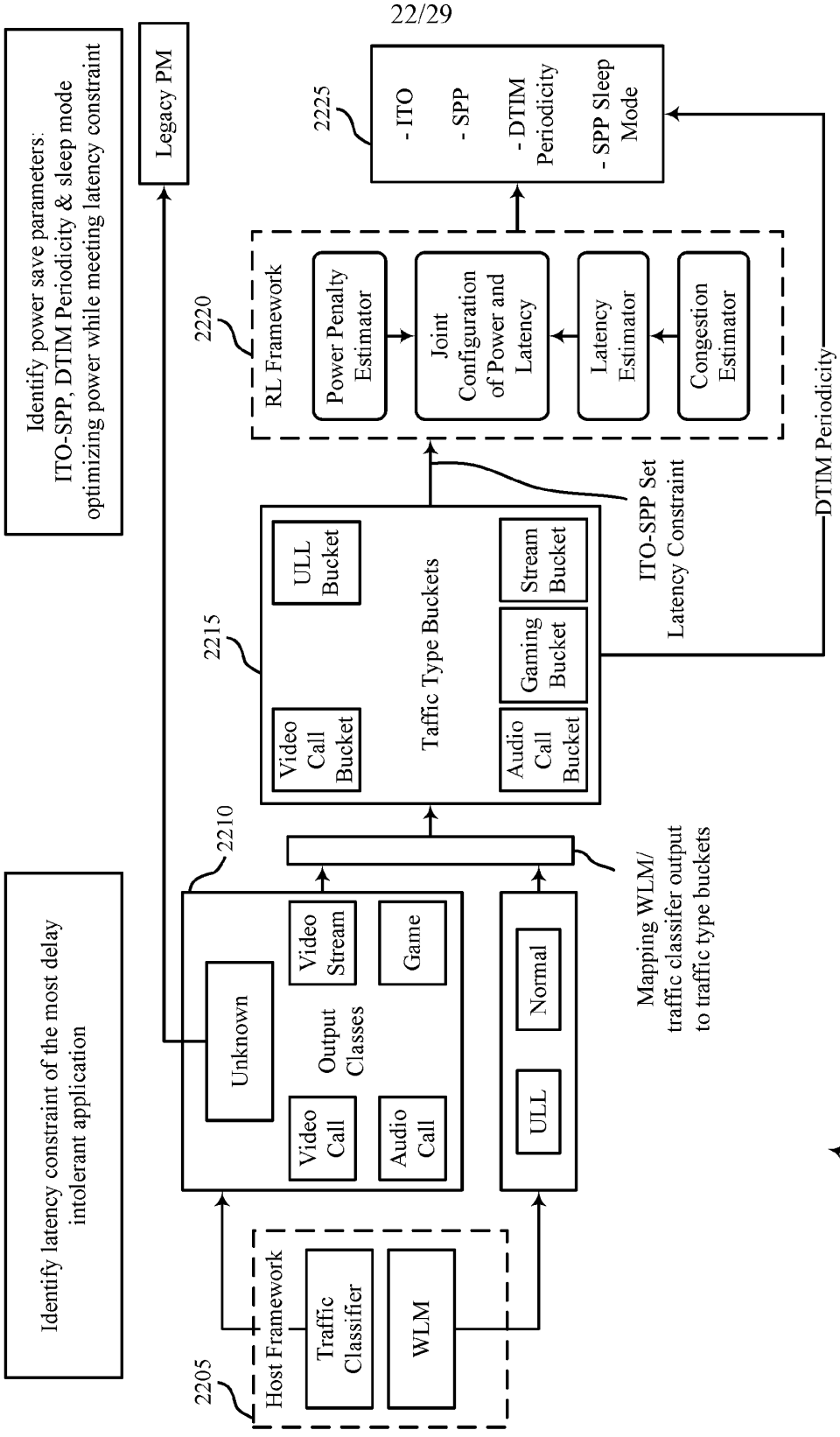
Identify power save parameters:
ITO-SPP, DTIM Periodicity & sleep mode
optimizing power while meeting latency constraint
Legacy PM
2225
- ITO
- SPP
- DTIM Periodicity
- SPP Sleep Mode
2220
RL Framework
Power Penalty Estimator
Joint Configuration of Power and Latency
Latency Estimator
Congestion Estimator
DTIM Periodicity
ITO-SPP Set
Latency Constraint
2215
Traffic Type Buckets
ULL Bucket
Video Call Bucket
Gaming Bucket
Stream Bucket
Audio Call Bucket
2210
Output Classes
Unknown
Video Stream
Game
Video Call
Audio Call
ULL
Normal
Mapping WLM/
traffic classifer output
to traffic type buckets
Identify latency constraint of the most delay
intolerant application
2205
Host Framework
Traffic Classifier
WLM
2200

Figure 22

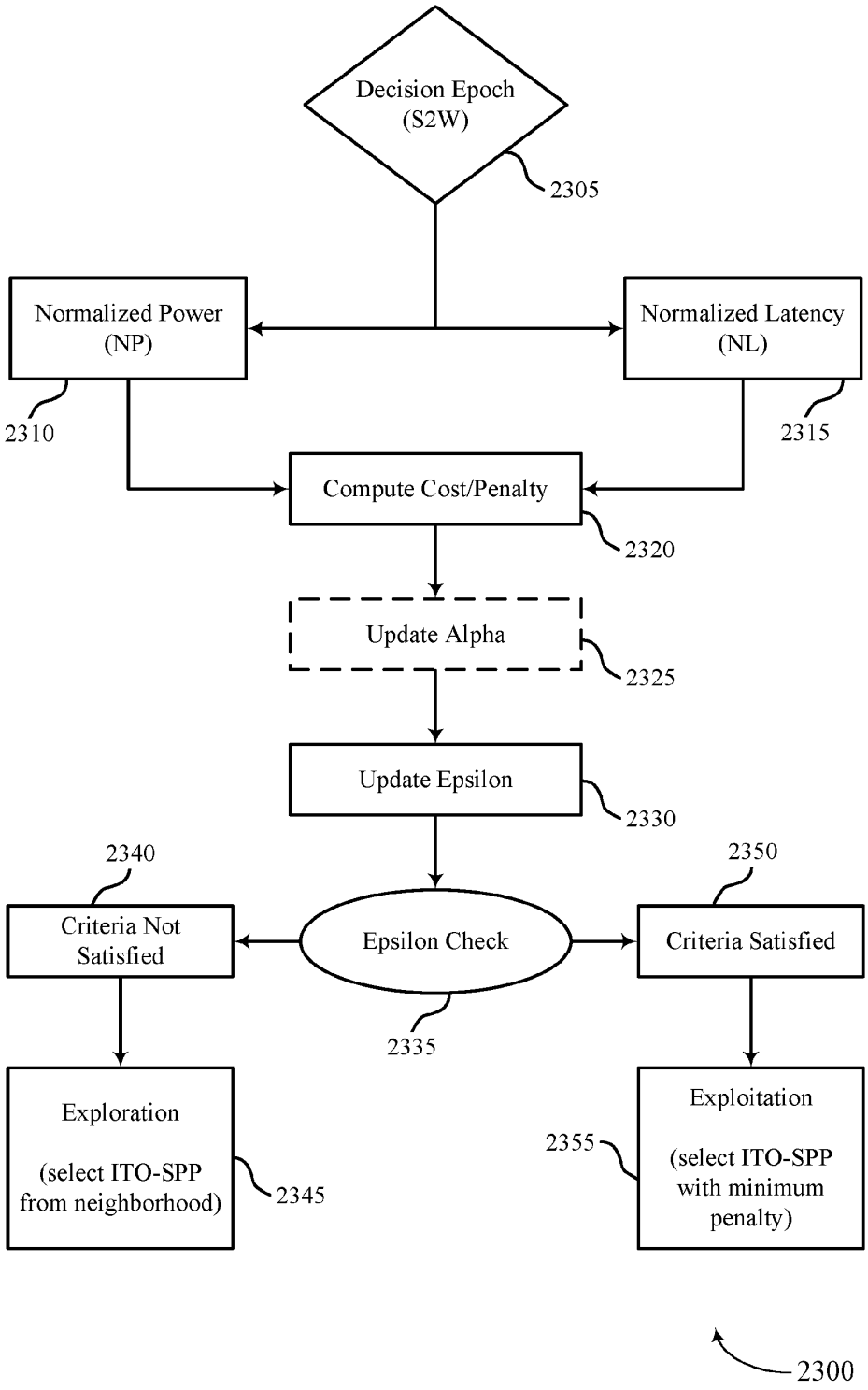
Decision Epoch
(S2W)
2305
Normalized Power
(NP)
2310
Normalized Latency
(NL)
2315
Compute Cost/Penalty
2320
Update Alpha
2325
Update Epsilon
2330
2340
Criteria Not
Satisfied
Epsilon Check
2335
2350
Criteria Satisfied
Exploration
(select ITO-SPP
from neighborhood)
2345
2355
Exploitation
(select ITO-SPP
with minimum
penalty)
2300

Figure 23

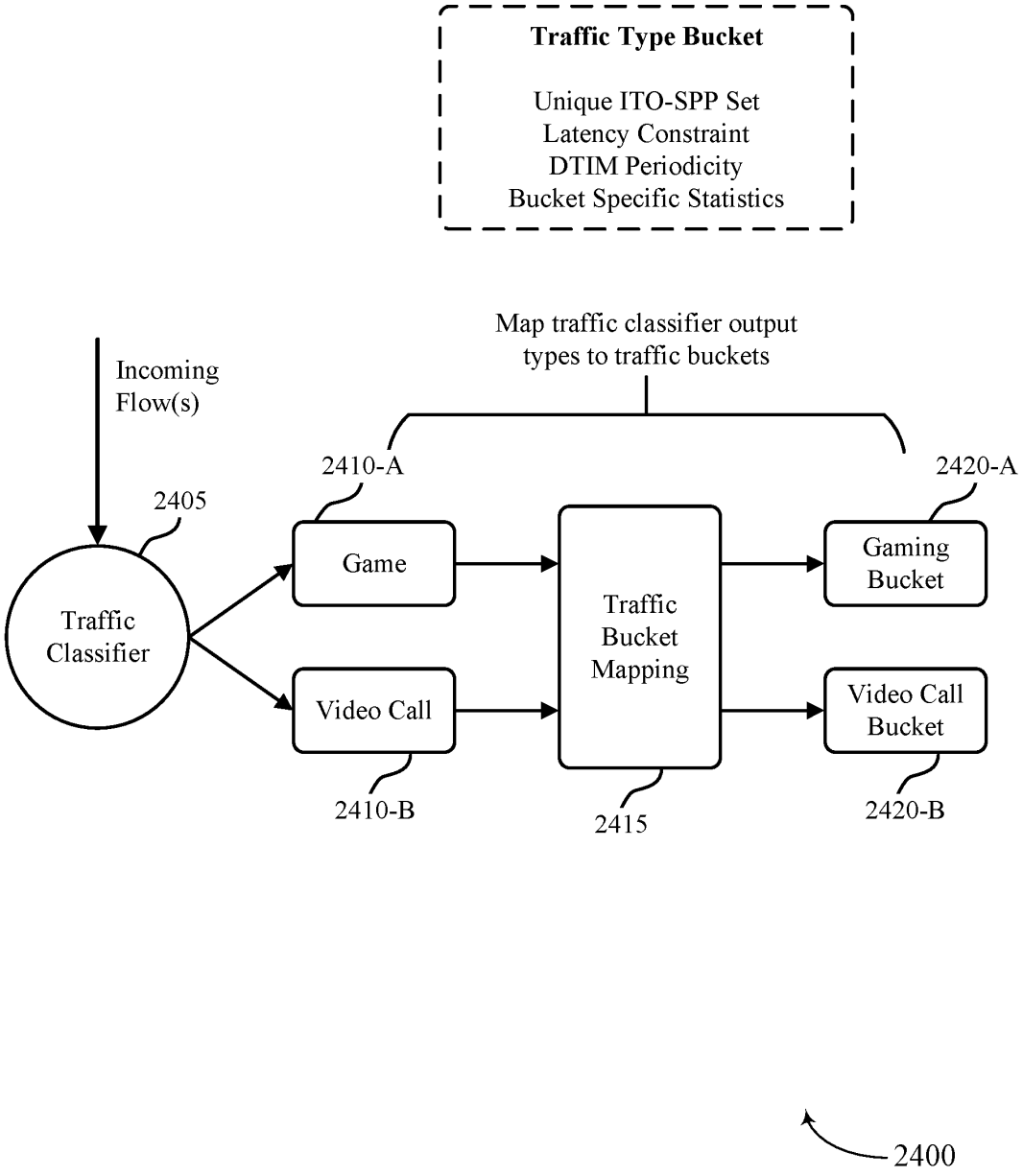
Traffic Type Bucket
Unique ITO-SPP Set
Latency Constraint
DTIM Periodicity
Bucket Specific Statistics
Map traffic classifier output types to traffic buckets
Incoming Flow(s)
2405
Traffic Classifier
2410-A
Game
2410-B
Video Call
Traffic Bucket Mapping
2415
2420-A
Gaming Bucket
Video Call Bucket
2420-B
2400

Figure 24

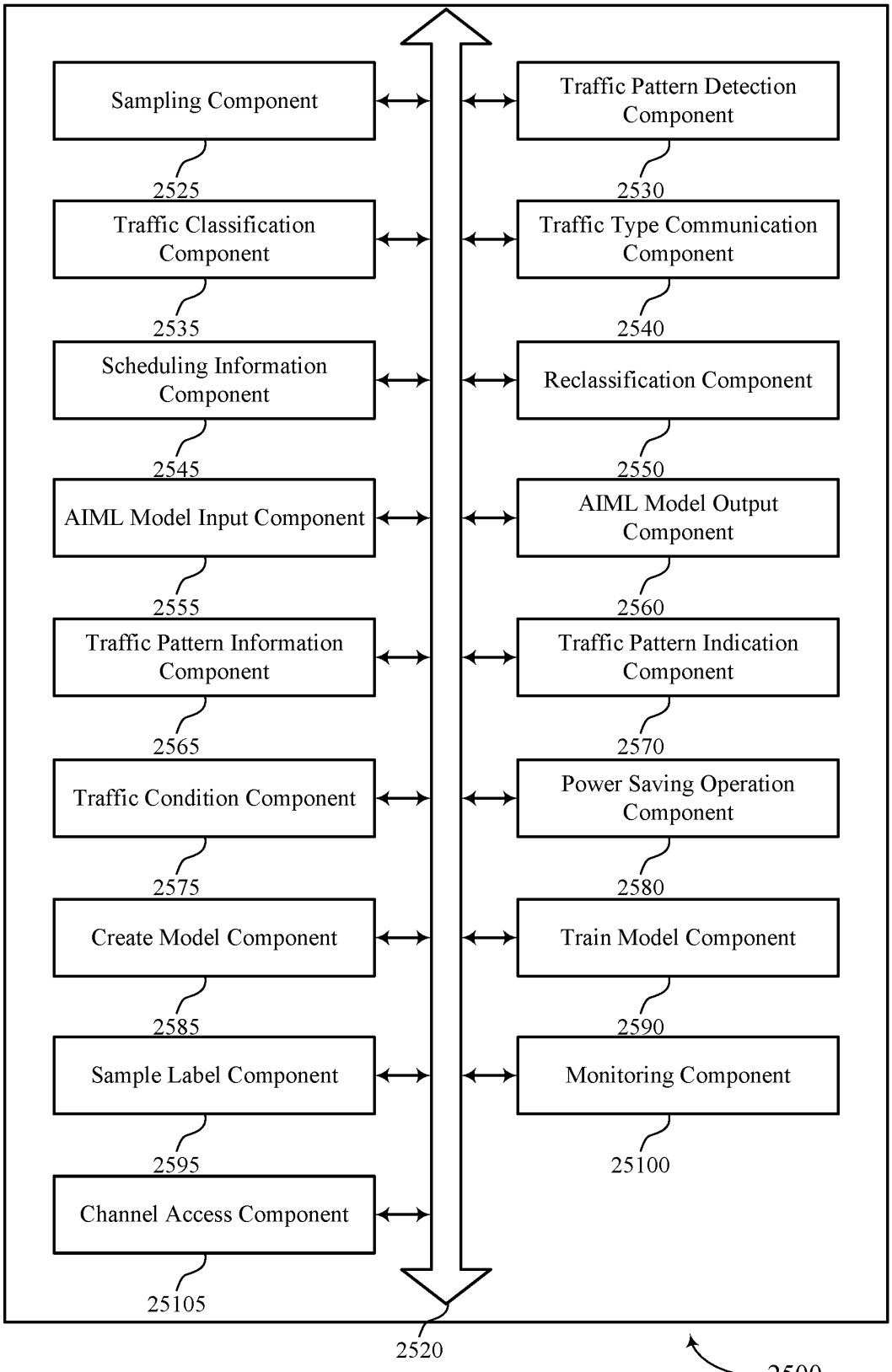
Sampling Component
2525
Traffic Classification Component
2535
Scheduling Information Component
2545
AIML Model Input Component
2555
Traffic Pattern Information Component
2565
Traffic Condition Component
2575
Create Model Component
2585
Sample Label Component
2595
Channel Access Component
25105
Traffic Pattern Detection Component
2530
Traffic Type Communication Component
2540
Reclassification Component
2550
AIML Model Output Component
2560
Traffic Pattern Indication Component
2570
Power Saving Operation Component
2580
Train Model Component
2590
Monitoring Component
25100
2520
2500

Figure 25

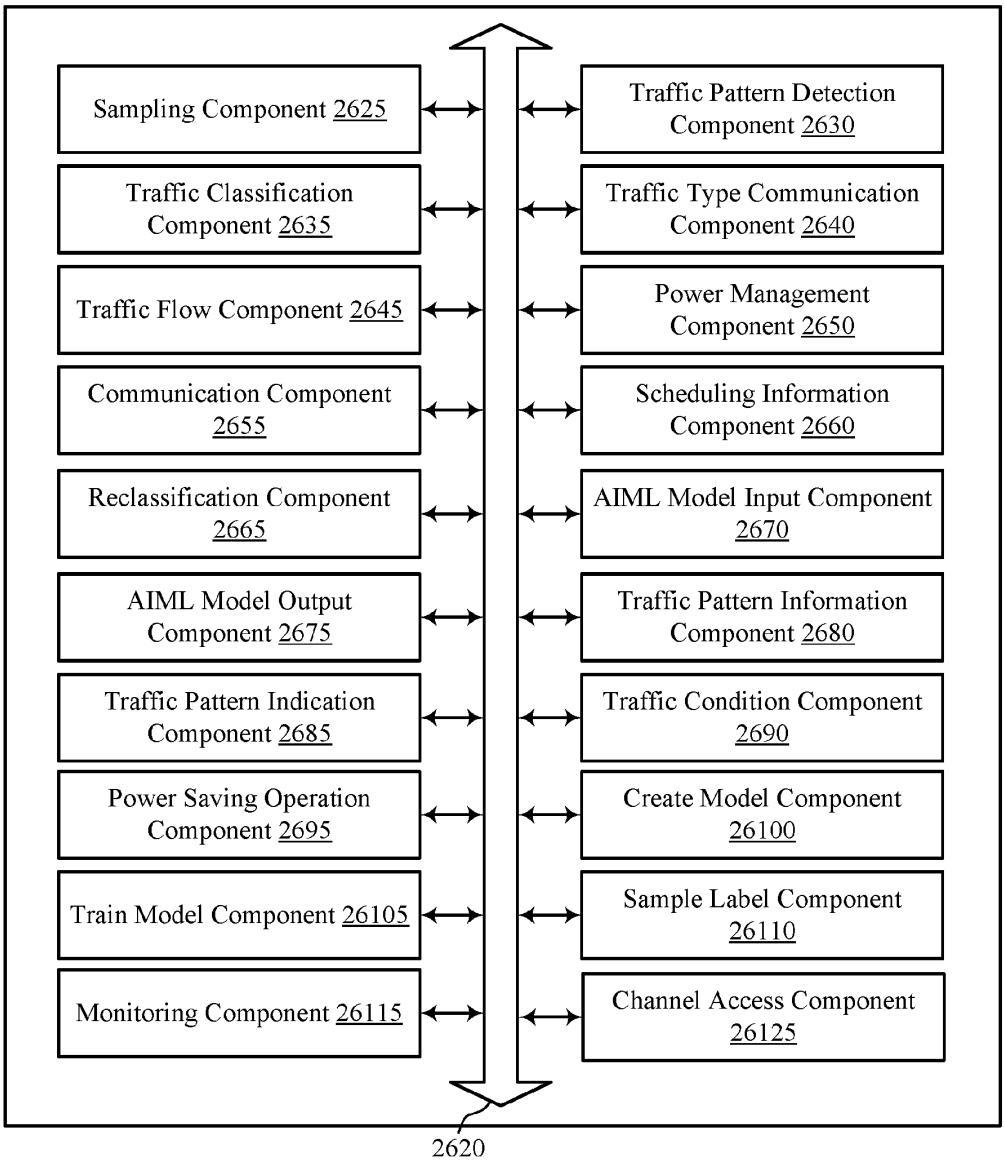

Figure 26

2600

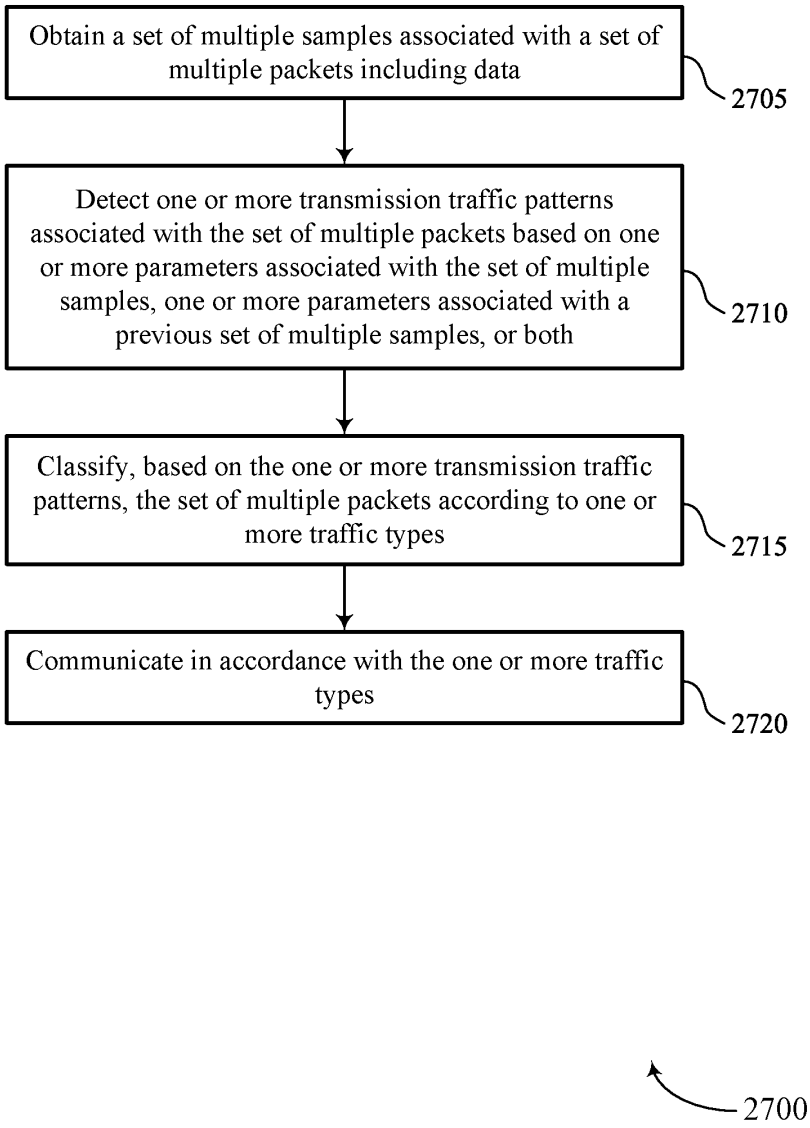
Obtain a set of multiple samples associated with a set of multiple packets including data
2705
Detect one or more transmission traffic patterns associated with the set of multiple packets based on one or more parameters associated with the set of multiple samples, one or more parameters associated with a previous set of multiple samples, or both
2710
Classify, based on the one or more transmission traffic patterns, the set of multiple packets according to one or more traffic types
2715
Communicate in accordance with the one or more traffic types
2720
2700

Figure 27

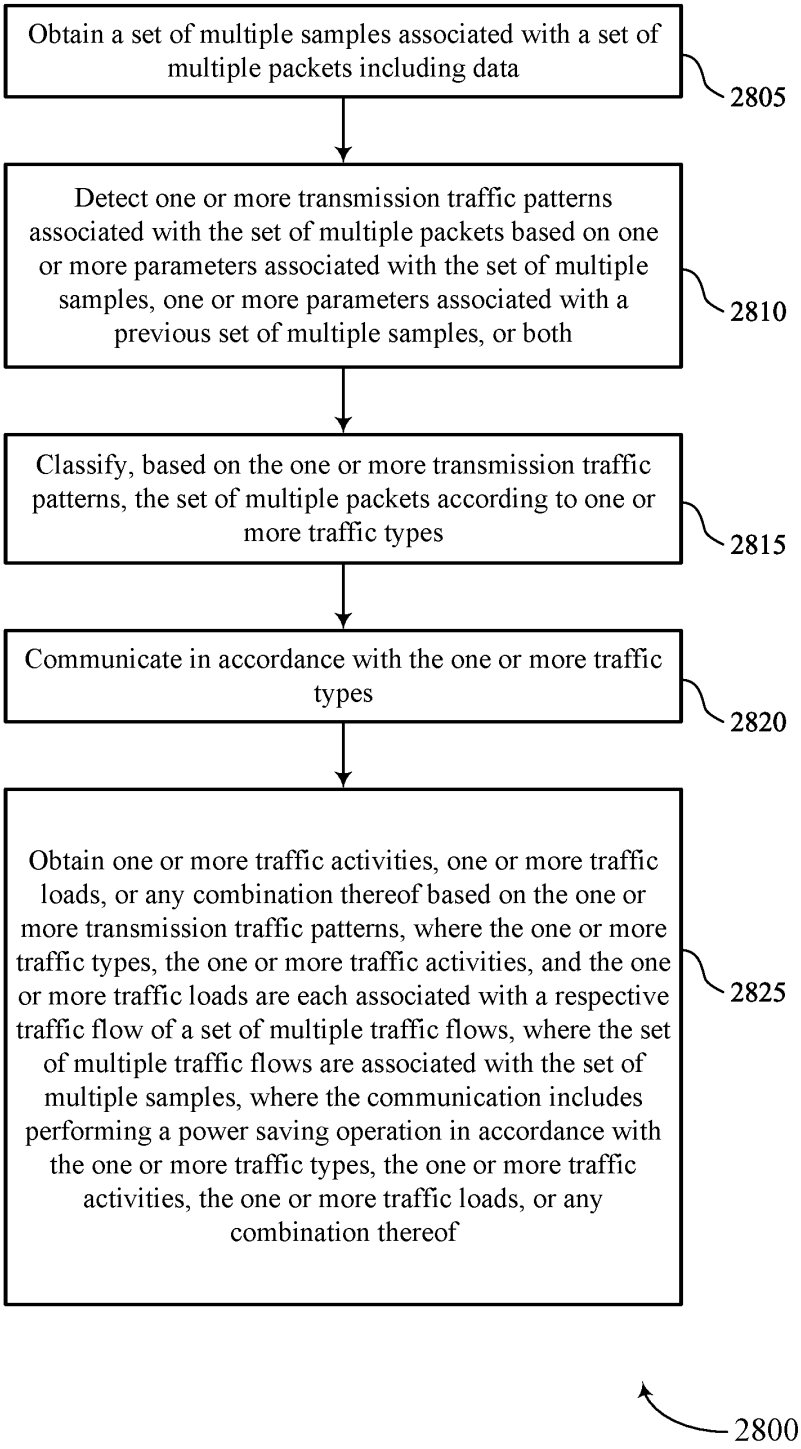
Obtain a set of multiple samples associated with a set of multiple packets including data
2805
Detect one or more transmission traffic patterns associated with the set of multiple packets based on one or more parameters associated with the set of multiple samples, one or more parameters associated with a previous set of multiple samples, or both
2810
Classify, based on the one or more transmission traffic patterns, the set of multiple packets according to one or more traffic types
2815
Communicate in accordance with the one or more traffic types
2820
Obtain one or more traffic activities, one or more traffic loads, or any combination thereof based on the one or more transmission traffic patterns, where the one or more traffic types, the one or more traffic activities, and the one or more traffic loads are each associated with a respective traffic flow of a set of multiple traffic flows, where the set of multiple traffic flows are associated with the set of multiple samples, where the communication includes performing a power saving operation in accordance with the one or more traffic types, the one or more traffic activities, the one or more traffic loads, or any combination thereof
2825
2800

Figure 28

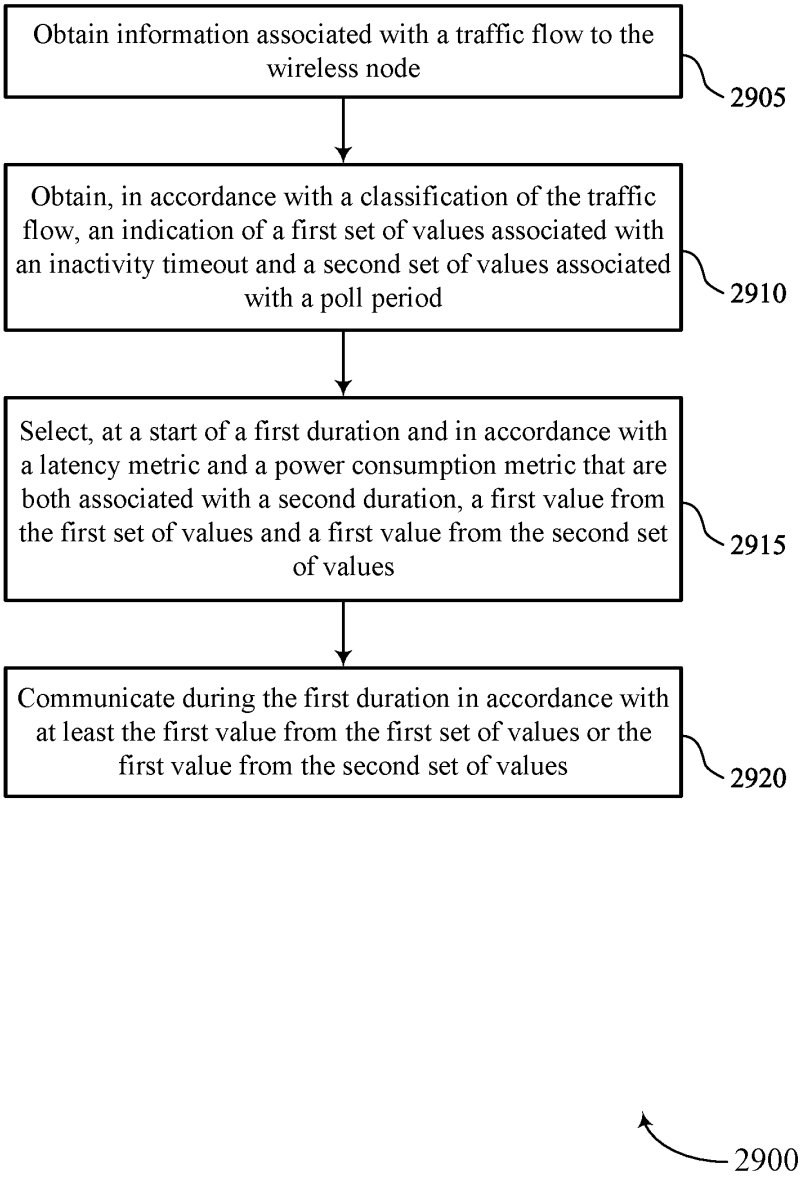
Obtain information associated with a traffic flow to the wireless node
2905
Obtain, in accordance with a classification of the traffic flow, an indication of a first set of values associated with an inactivity timeout and a second set of values associated with a poll period
2910
Select, at a start of a first duration and in accordance with a latency metric and a power consumption metric that are both associated with a second duration, a first value from the first set of values and a first value from the second set of values
2915
Communicate during the first duration in accordance with at least the first value from the first set of values or the first value from the second set of values
2920
2900

Figure 29