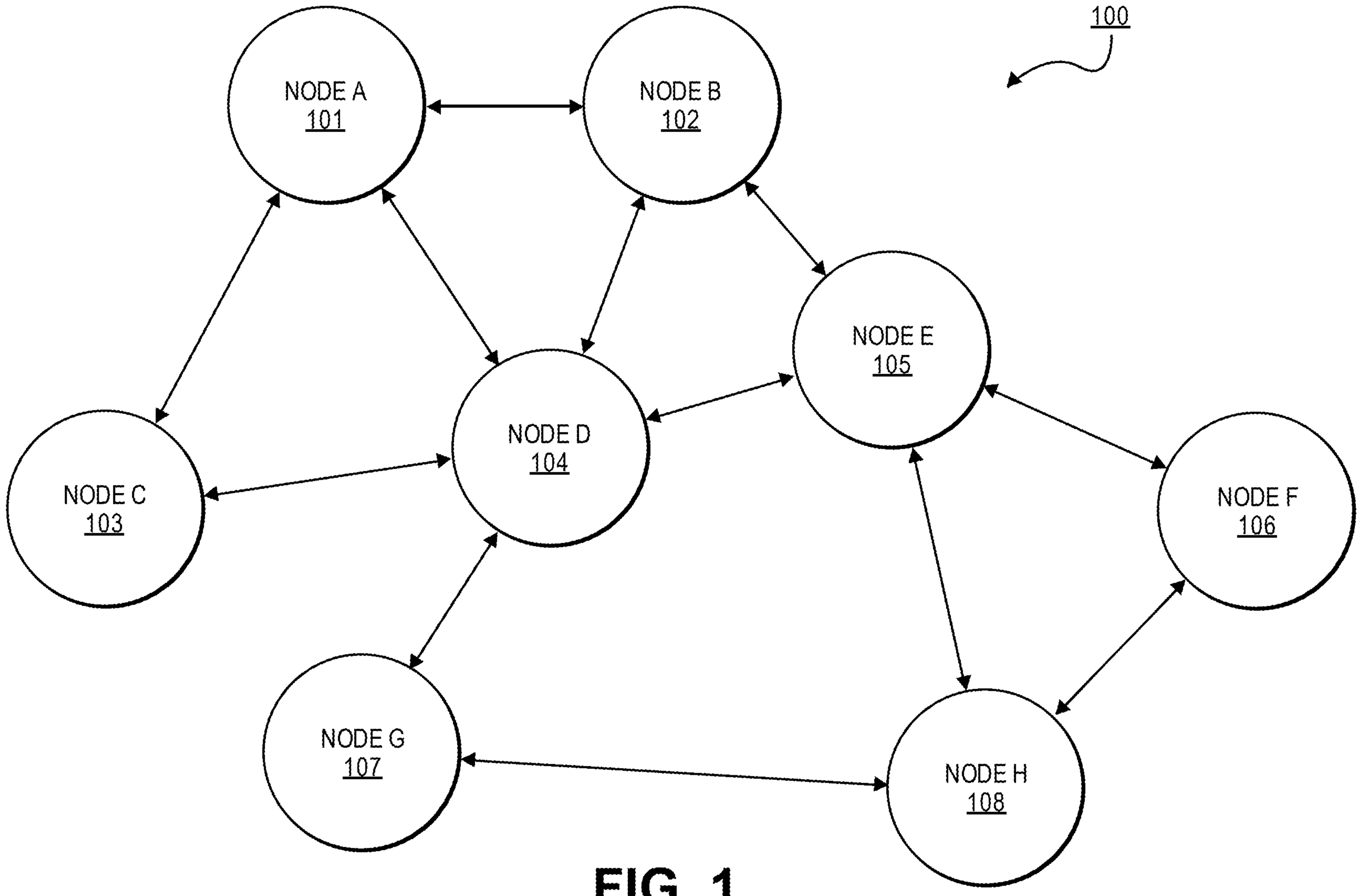

100
NODE A
101
NODE B
102
NODE C
103
NODE D
104
NODE E
105
NODE F
106
NODE G
107
NODE H
108

FIG. 1

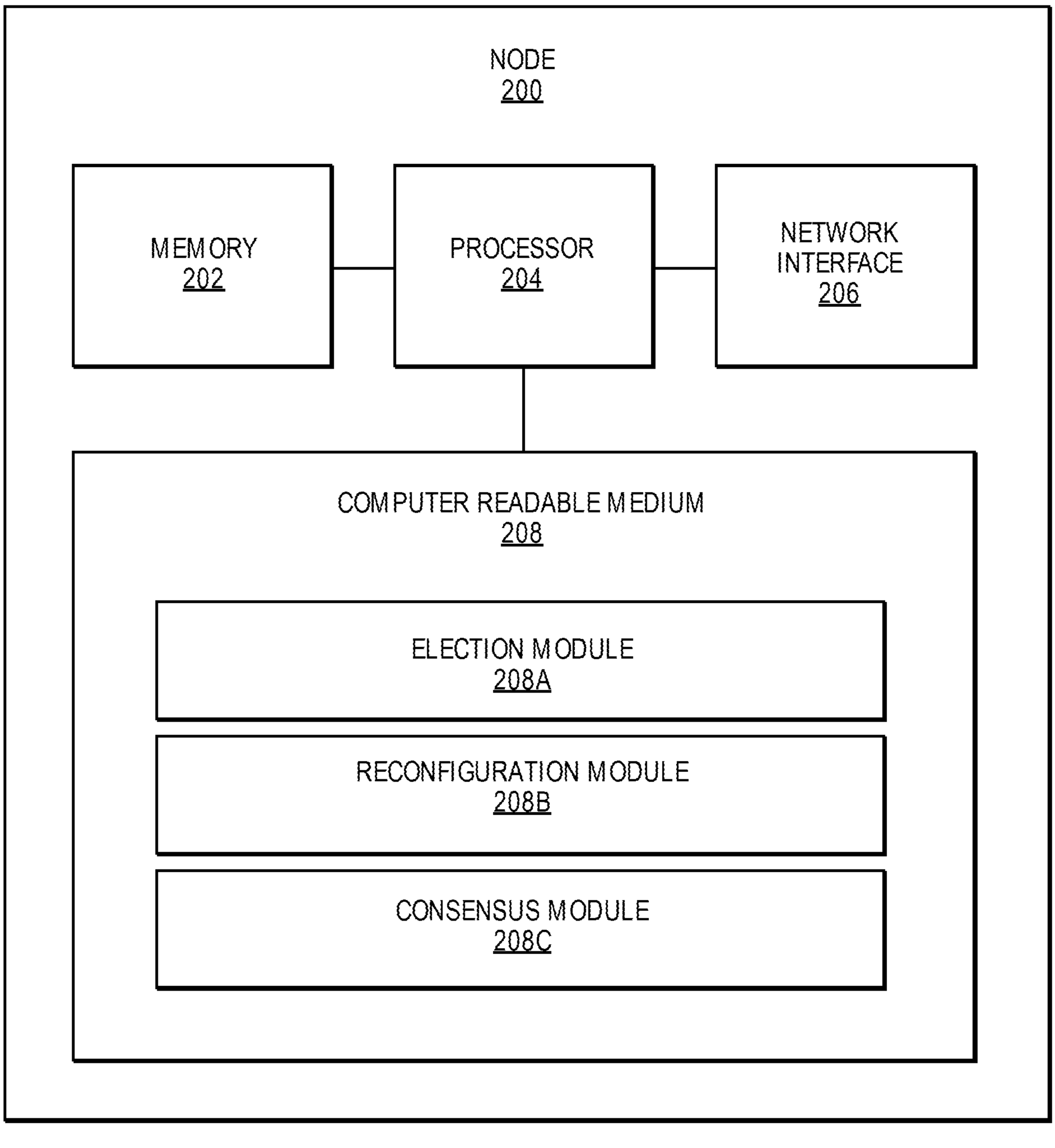

NODE
200
MEMORY
202
PROCESSOR
204
NETWORK
INTERFACE
206
COMPUTER READABLE MEDIUM
208
ELECTION MODULE
208A
RECONFIGURATION MODULE
208B
CONSENSUS MODULE
208C

FIG. 2

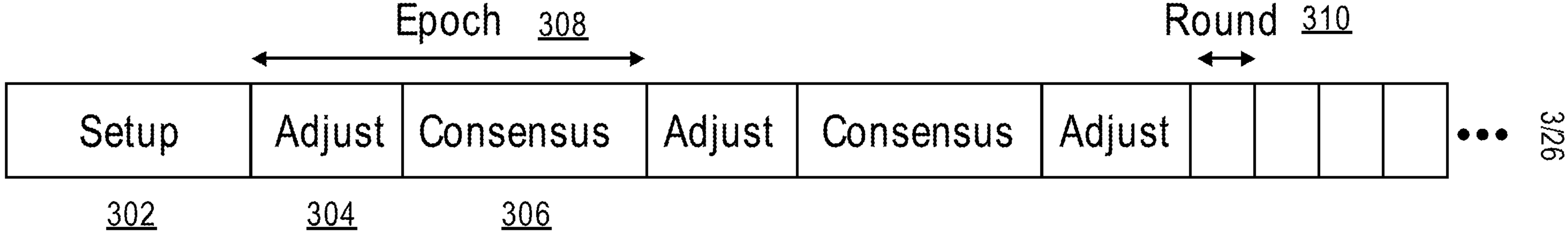

Epoch 308
Round 310
Setup
Adjust
Consensus
Adjust
Consensus
Adjust
302
304
306
3/26

FIG. 3

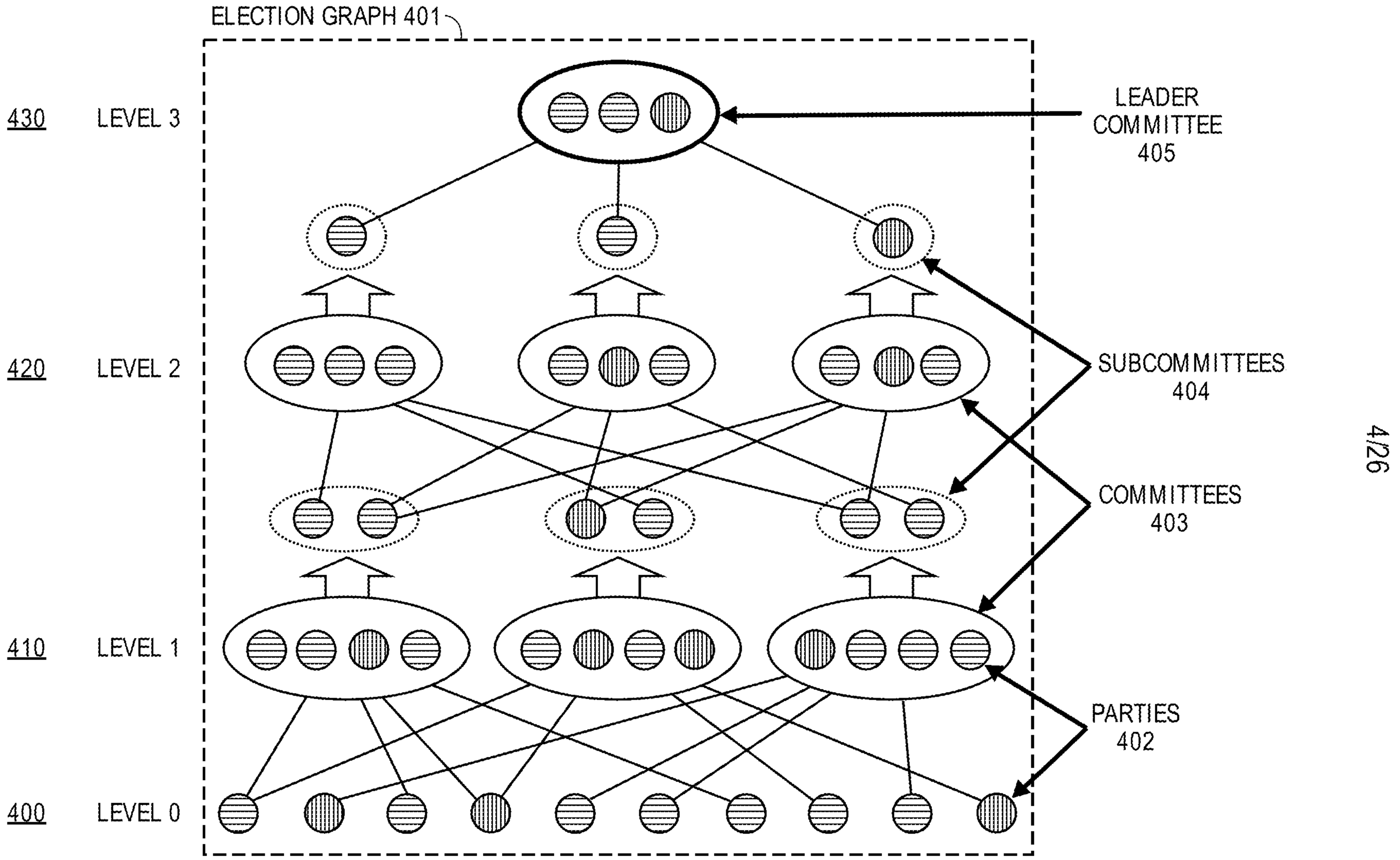

ELECTION GRAPH 401
430 LEVEL 3
420 LEVEL 2
410 LEVEL 1
400 LEVEL 0
LEADER COMMITTEE 405
SUBCOMMITTEES 404
COMMITTEES 403
PARTIES 402
426

FIG. 4

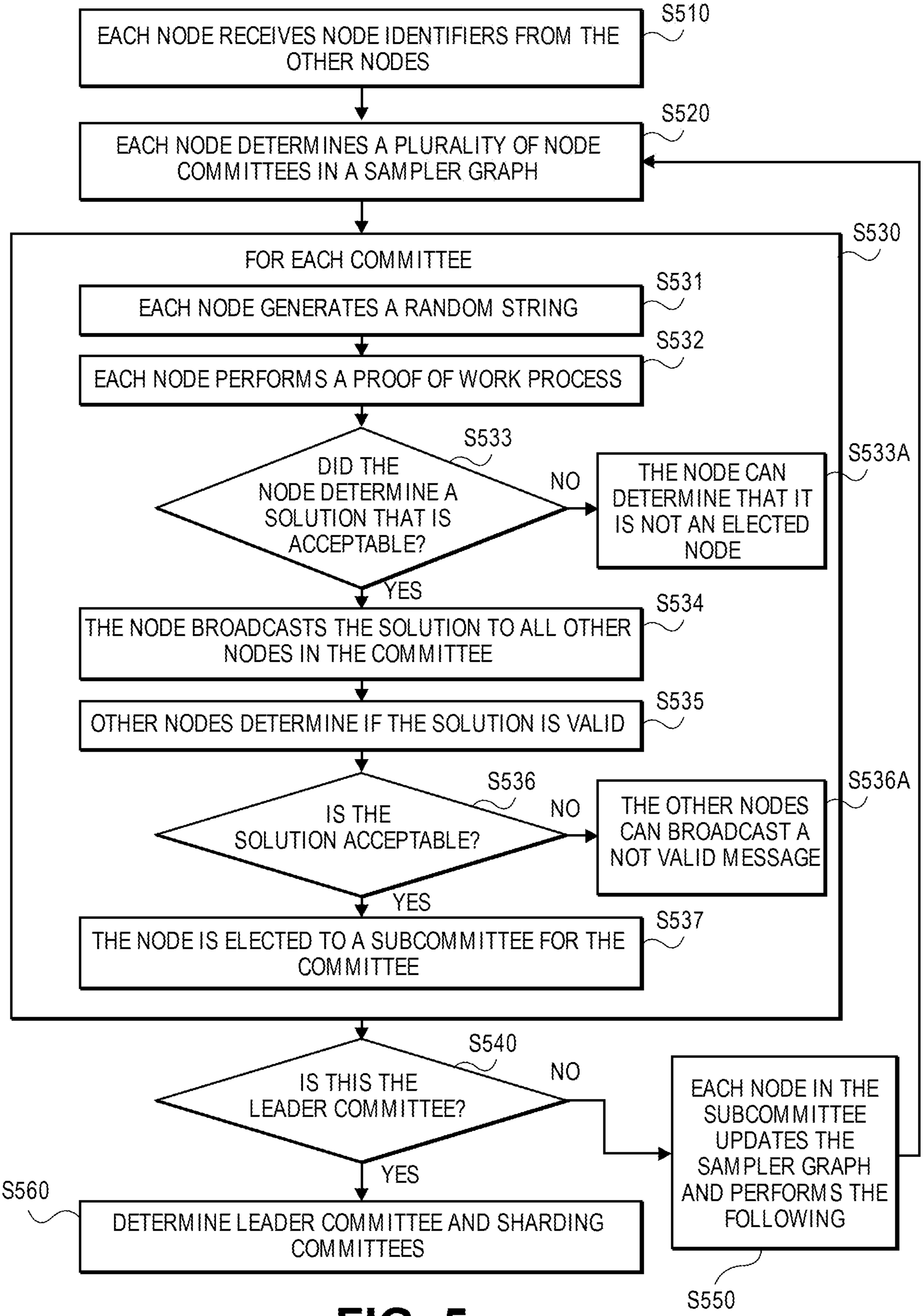

EACH NODE RECEIVES NODE IDENTIFIERS FROM THE OTHER NODES
S510
EACH NODE DETERMINES A PLURALITY OF NODE COMMITTEES IN A SAMPLER GRAPH
S520
FOR EACH COMMITTEE
S530
EACH NODE GENERATES A RANDOM STRING
S531
EACH NODE PERFORMS A PROOF OF WORK PROCESS
S532
DID THE NODE DETERMINE A SOLUTION THAT IS ACCEPTABLE?
S533
NO
THE NODE CAN DETERMINE THAT IT IS NOT AN ELECTED NODE
S533A
YES
THE NODE BROADCASTS THE SOLUTION TO ALL OTHER NODES IN THE COMMITTEE
S534
OTHER NODES DETERMINE IF THE SOLUTION IS VALID
S535
IS THE SOLUTION ACCEPTABLE?
S536
NO
THE OTHER NODES CAN BROADCAST A NOT VALID MESSAGE
S536A
YES
THE NODE IS ELECTED TO A SUBCOMMITTEE FOR THE COMMITTEE
S537
IS THIS THE LEADER COMMITTEE?
S540
NO
EACH NODE IN THE SUBCOMMITTEE UPDATES THE SAMPLER GRAPH AND PERFORMS THE FOLLOWING
S550
YES
DETERMINE LEADER COMMITTEE AND SHARDING COMMITTEES
S560

FIG. 5

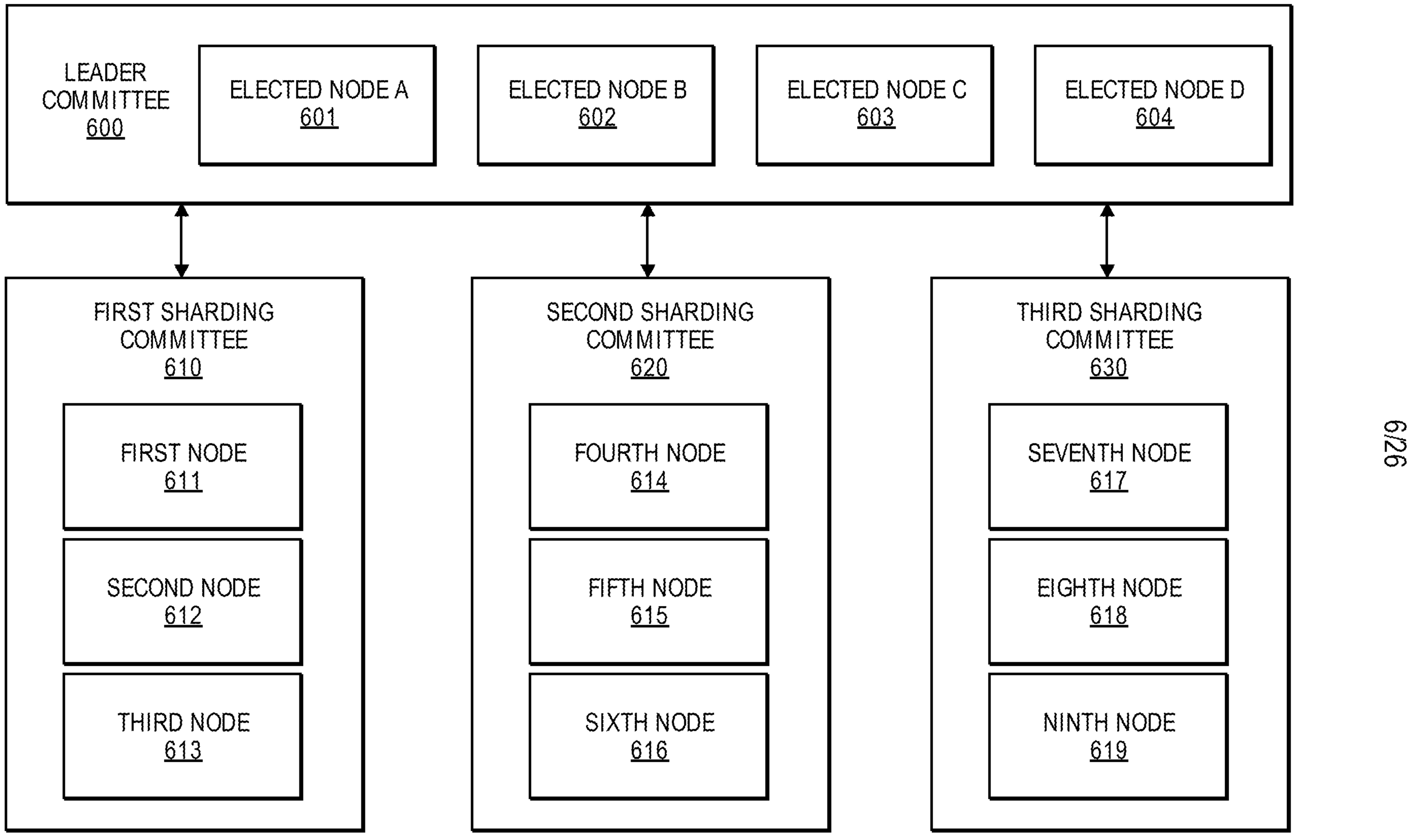

LEADER COMMITTEE 600
ELECTED NODE A 601
ELECTED NODE B 602
ELECTED NODE C 603
ELECTED NODE D 604
FIRST SHARDING COMMITTEE 610
FIRST NODE 611
SECOND NODE 612
THIRD NODE 613
SECOND SHARDING COMMITTEE 620
FOURTH NODE 614
FIFTH NODE 615
SIXTH NODE 616
THIRD SHARDING COMMITTEE 630
SEVENTH NODE 617
EIGHTH NODE 618
NINTH NODE 619

FIG. 6

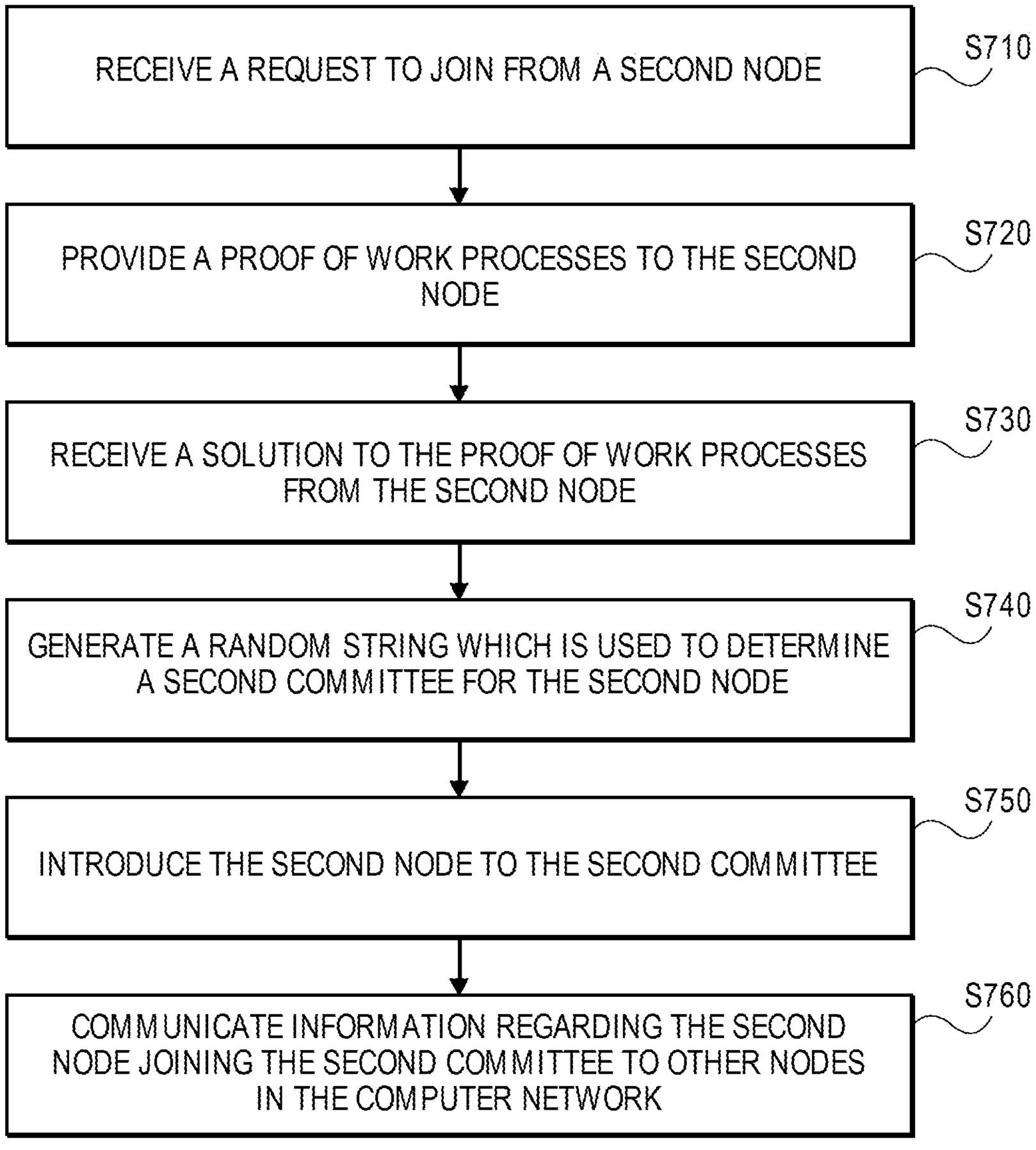

RECEIVE A REQUEST TO JOIN FROM A SECOND NODE
S710
PROVIDE A PROOF OF WORK PROCESSES TO THE SECOND NODE
S720
RECEIVE A SOLUTION TO THE PROOF OF WORK PROCESSES FROM THE SECOND NODE
S730
GENERATE A RANDOM STRING WHICH IS USED TO DETERMINE A SECOND COMMITTEE FOR THE SECOND NODE
S740
INTRODUCE THE SECOND NODE TO THE SECOND COMMITTEE
S750
COMMUNICATE INFORMATION REGARDING THE SECOND NODE JOINING THE SECOND COMMITTEE TO OTHER NODES IN THE COMPUTER NETWORK
S760

FIG. 7

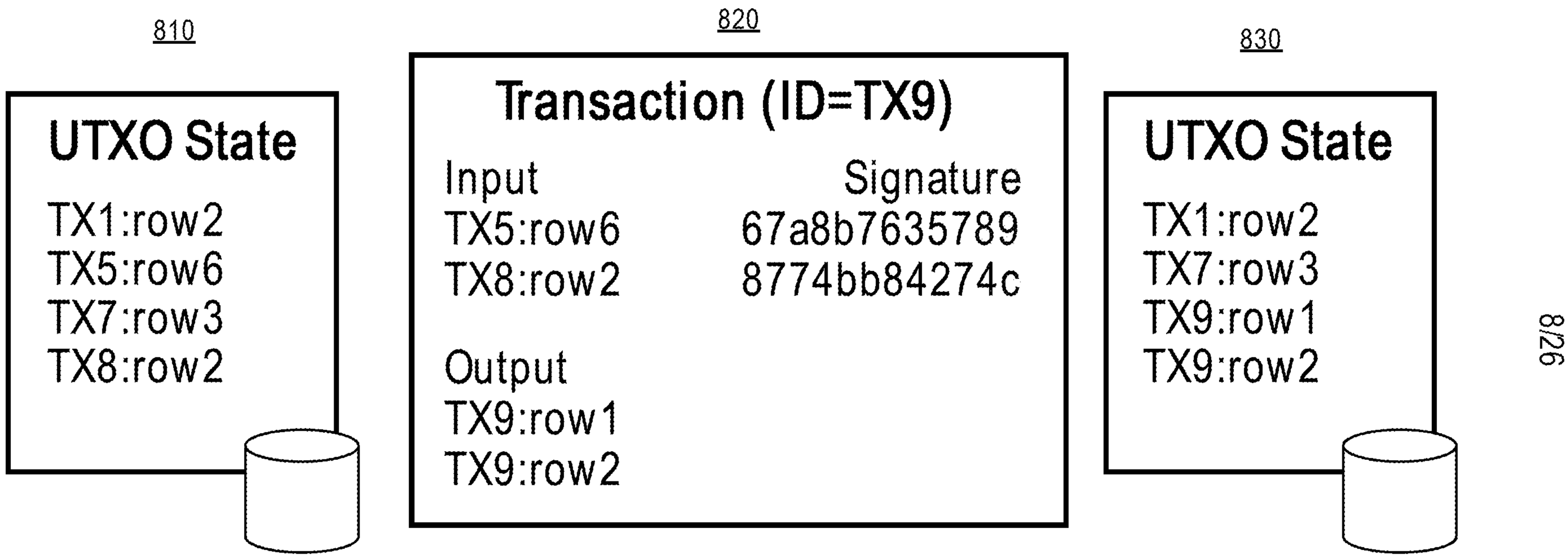

810
UTXO State
TX1:row2
TX5:row6
TX7:row3
TX8:row2
820
Transaction (ID=TX9)
Input
Signature
TX5:row6
67a8b7635789
TX8:row2
8774bb84274c
Output
TX9:row1
TX9:row2
830
UTXO State
TX1:row2
TX7:row3
TX9:row1
TX9:row2

FIG. 8

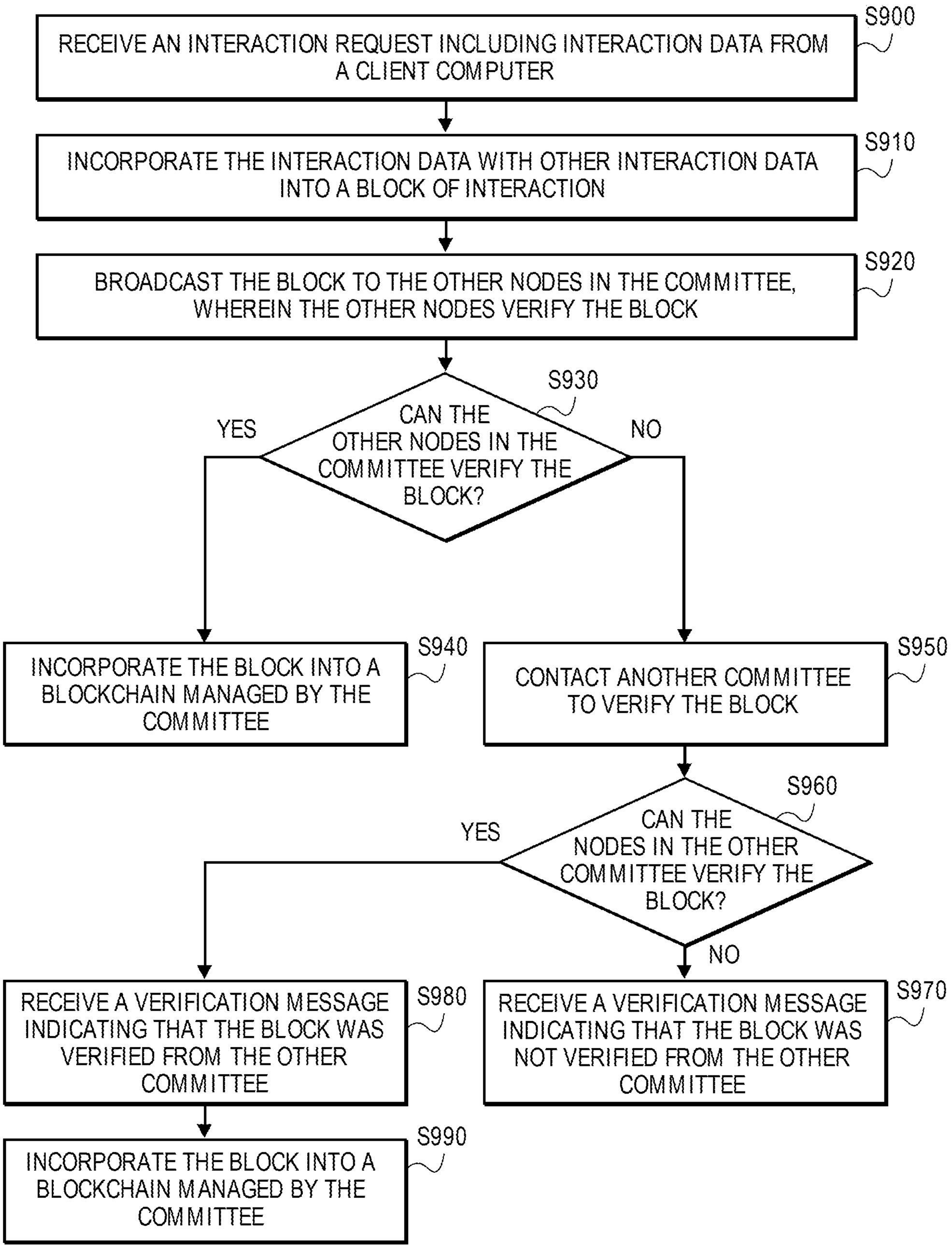

RECEIVE AN INTERACTION REQUEST INCLUDING INTERACTION DATA FROM A CLIENT COMPUTER
S900
INCORPORATE THE INTERACTION DATA WITH OTHER INTERACTION DATA INTO A BLOCK OF INTERACTION
S910
BROADCAST THE BLOCK TO THE OTHER NODES IN THE COMMITTEE, WHEREIN THE OTHER NODES VERIFY THE BLOCK
S920
S930
CAN THE OTHER NODES IN THE COMMITTEE VERIFY THE BLOCK?
YES
NO
INCORPORATE THE BLOCK INTO A BLOCKCHAIN MANAGED BY THE COMMITTEE
S940
CONTACT ANOTHER COMMITTEE TO VERIFY THE BLOCK
S950
S960
CAN THE NODES IN THE OTHER COMMITTEE VERIFY THE BLOCK?
YES
NO
RECEIVE A VERIFICATION MESSAGE INDICATING THAT THE BLOCK WAS VERIFIED FROM THE OTHER COMMITTEE
S980
RECEIVE A VERIFICATION MESSAGE INDICATING THAT THE BLOCK WAS NOT VERIFIED FROM THE OTHER COMMITTEE
S970
INCORPORATE THE BLOCK INTO A BLOCKCHAIN MANAGED BY THE COMMITTEE
S990

FIG. 9

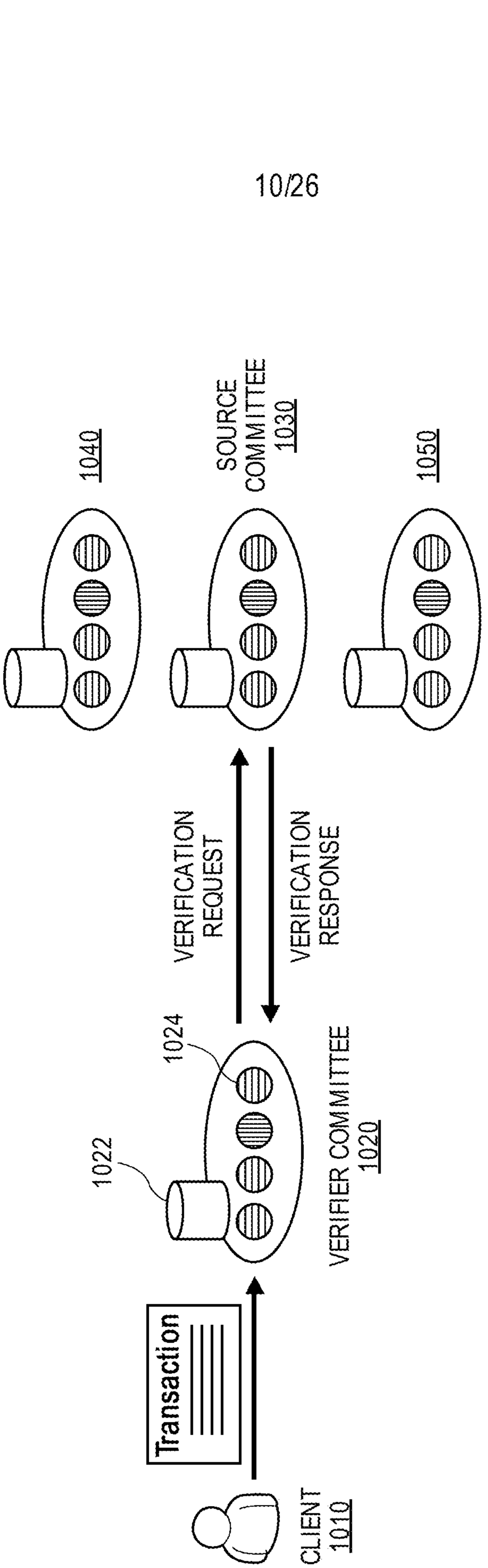

CLIENT
1010
Transaction
VERIFIER COMMITTEE
1020
1022
1024
VERIFICATION
REQUEST
VERIFICATION
RESPONSE
SOURCE
COMMITTEE
1030
1040
1050

FIG. 10

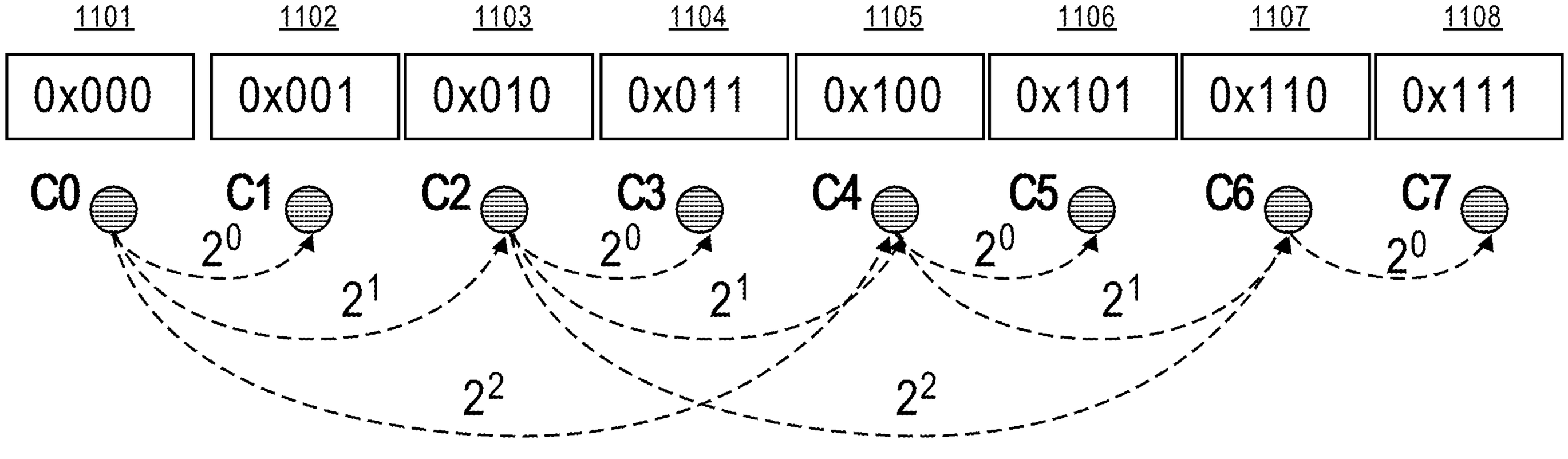

1101
1102
1103
1104
1105
1106
1107
1108
0x000
0x001
0x010
0x011
0x100
0x101
0x110
0x111
C0
C1
C2
C3
C4
C5
C6
C7
2^0
2^1
2^2

FIG. 11

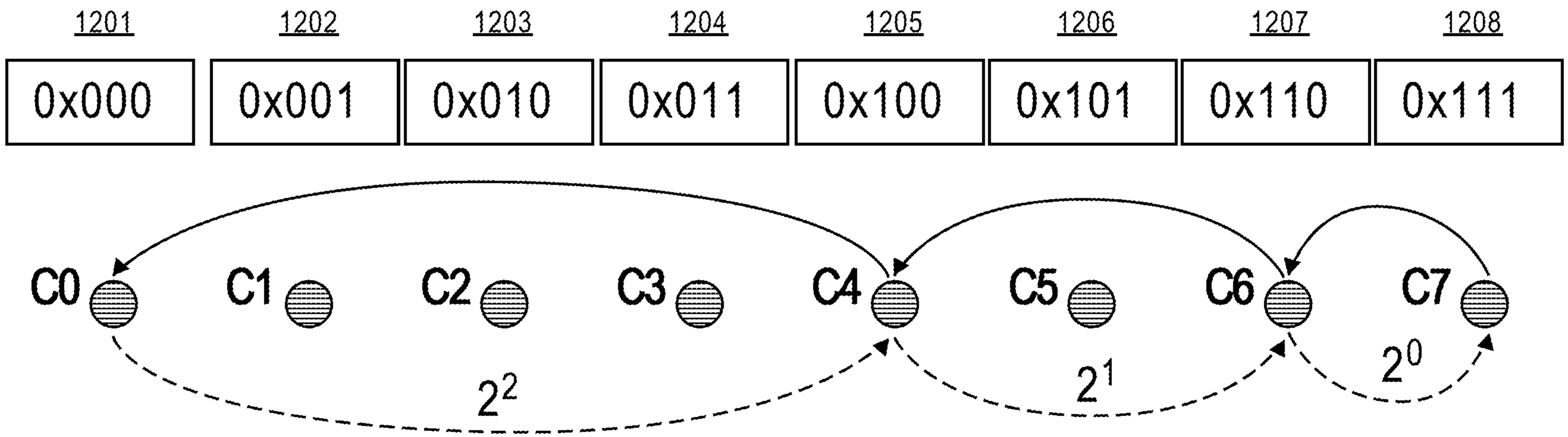

1201
1202
1203
1204
1205
1206
1207
1208
0x000
0x001
0x010
0x011
0x100
0x101
0x110
0x111
C0
C1
C2
C3
C4
C5
C6
C7
2^2
2^1
2^0

FIG. 12

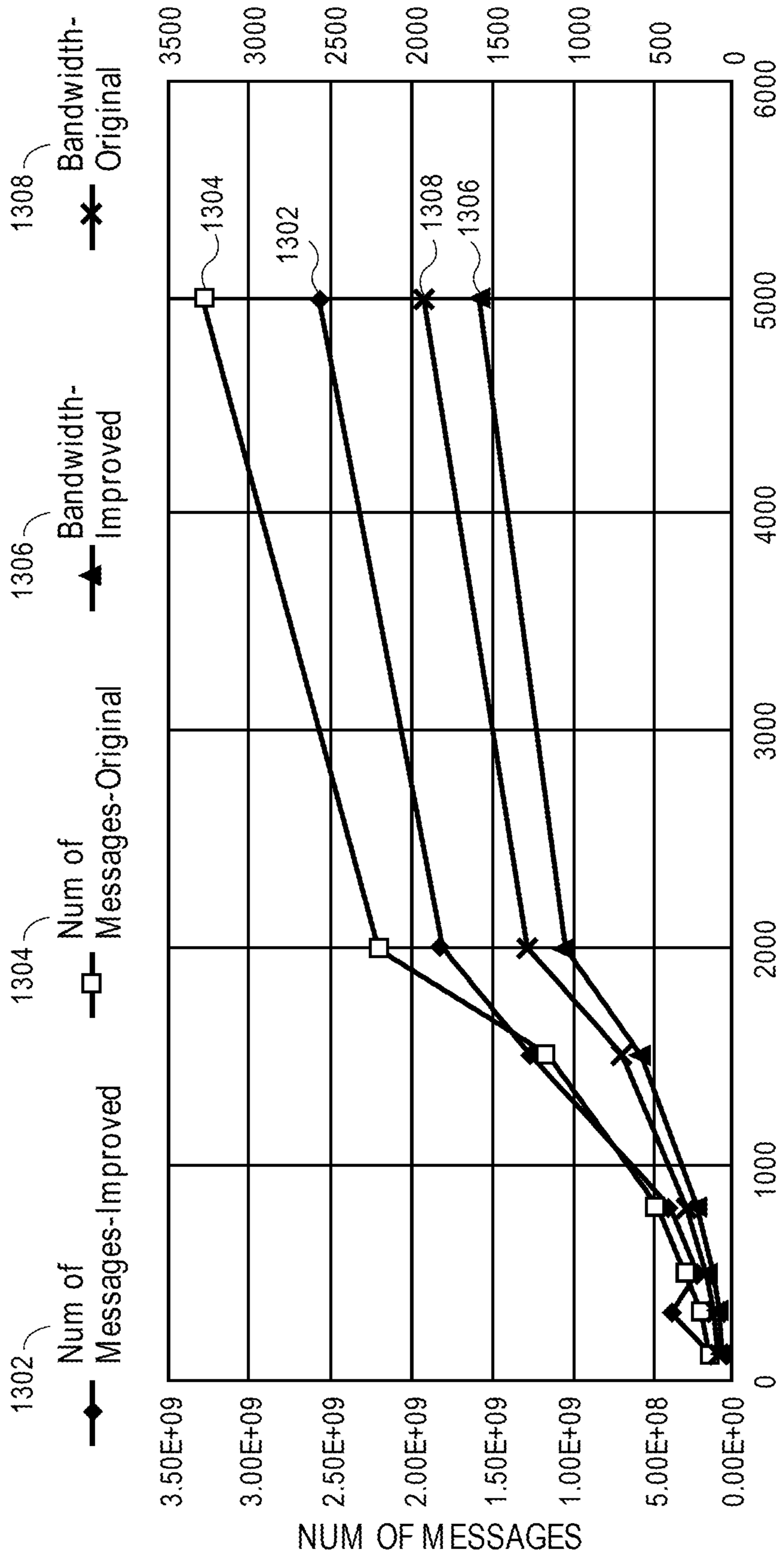

NUM OF MESSAGES VERSUS NUM OF NODES
1306
Bandwidth-Improved
1308
Bandwidth-Original
1304
Num of Messages-Original
1302
Num of Messages-Improved
NUMBER OF PARTIES
0
1000
2000
3000
4000
5000
6000
NUM OF MESSAGES
0.00E+00
5.00E+08
1.00E+09
1.50E+09
2.00E+09
2.50E+09
3.00E+09
3.50E+09
BANDWIDTH (MB)
0
500
1000
1500
2000
2500
3000
3500

FIG. 13

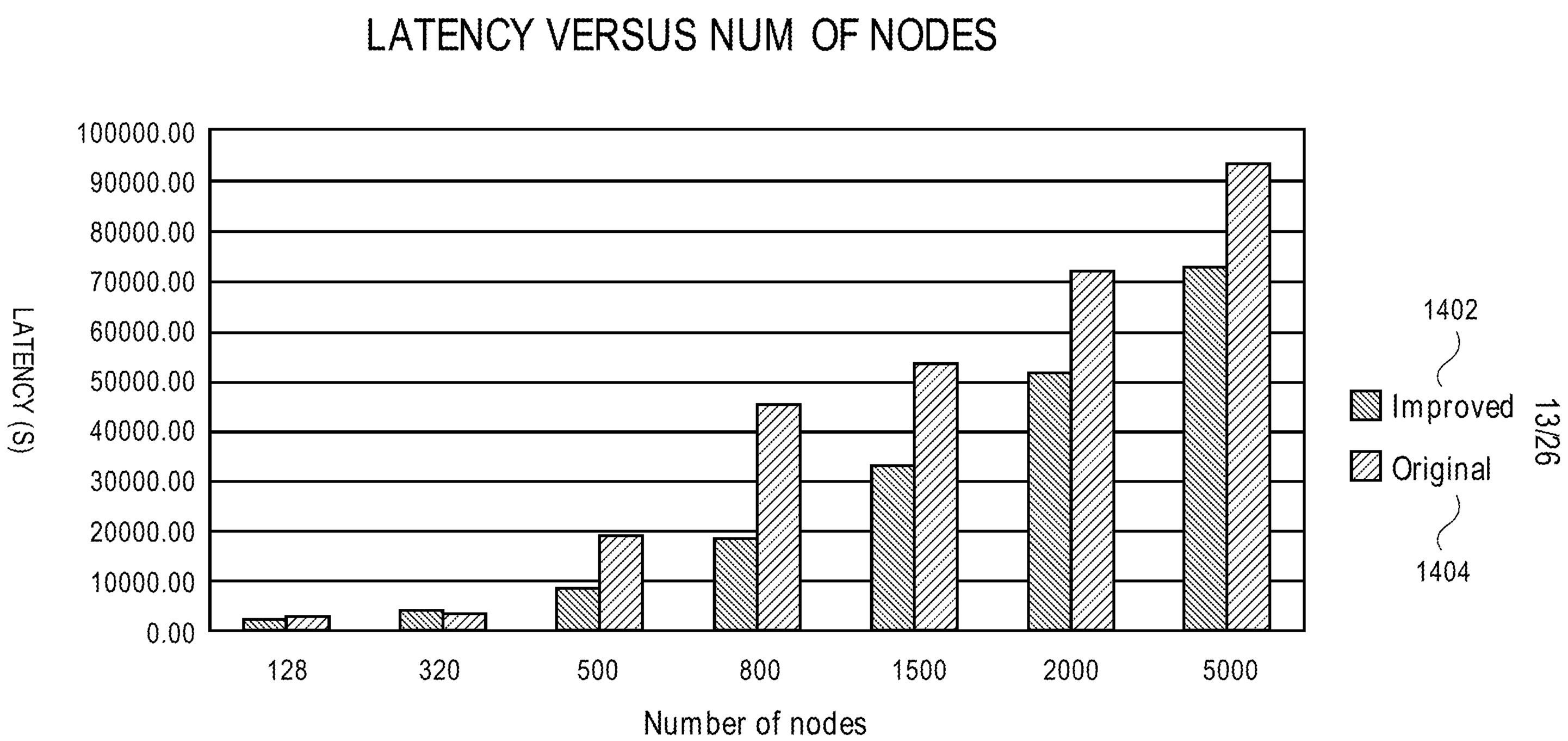

LATENCY VERSUS NUM OF NODES
100000.00
90000.00
80000.00
70000.00
60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
LATENCY (S)
128
320
500
800
1500
2000
5000
Number of nodes
1402
Improved
Original
1404
13/26

FIG. 14

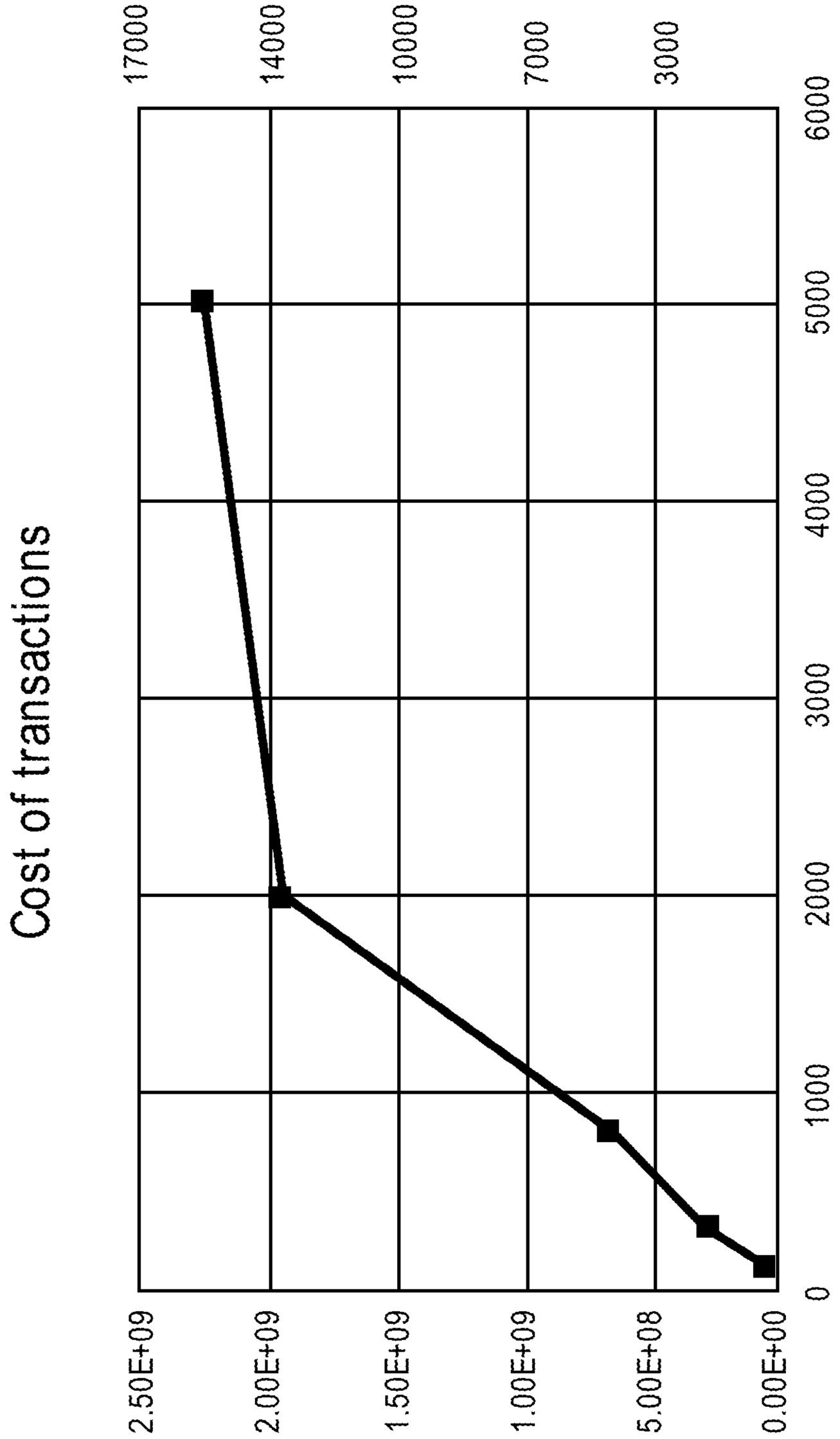

Bandwidth (MB)
17000
14000
10000
7000
3000
0
Cost of transactions
2.50E+09
2.00E+09
1.50E+09
1.00E+09
5.00E+08
0.00E+00
Number of parties
3000
4000
5000
6000
2000
1000
0
Number of messages

FIG. 15

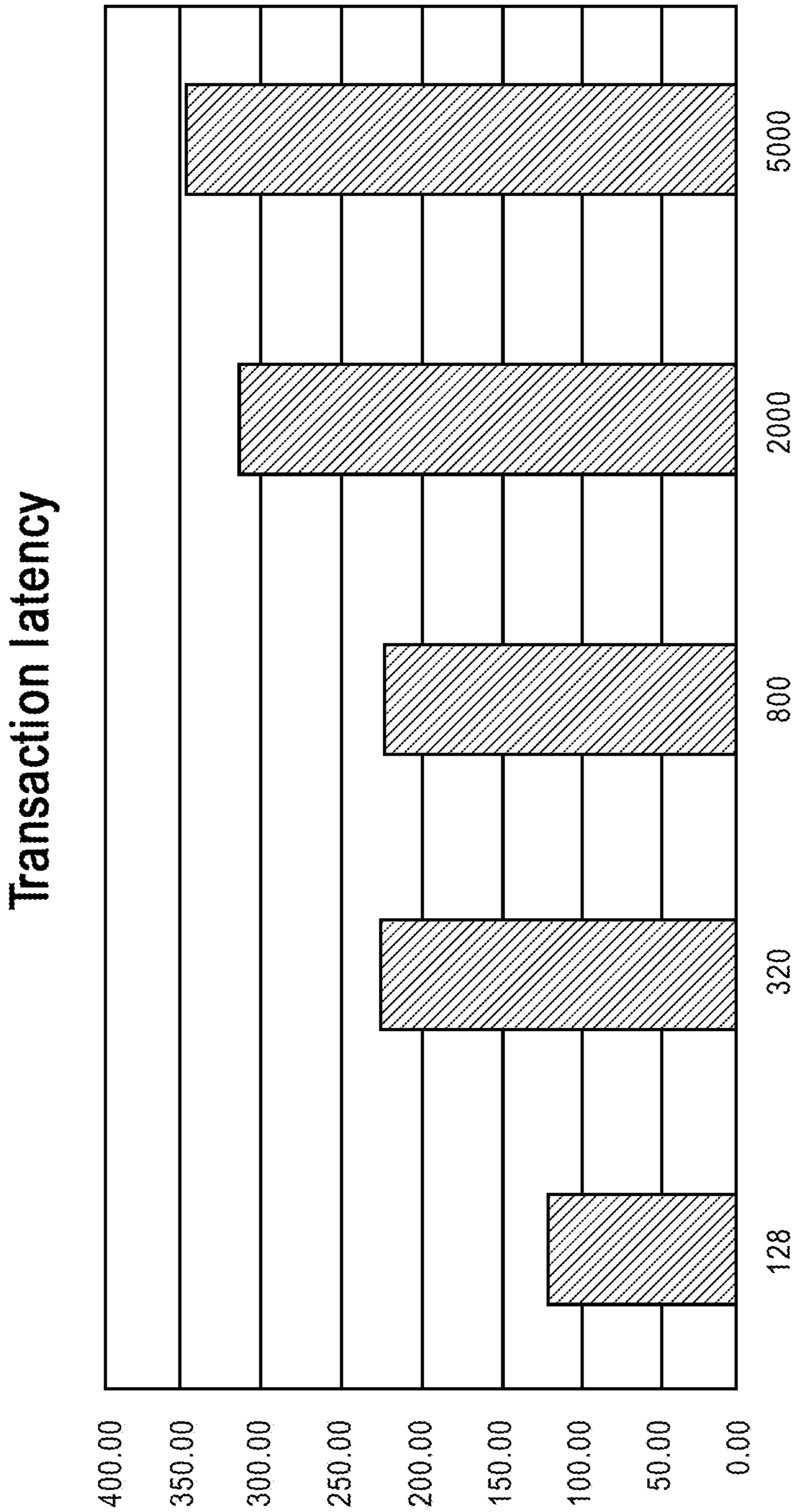

Transaction latency
5000
2000
800
320
128
Number of parties
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Latency (S)

FIG. 16

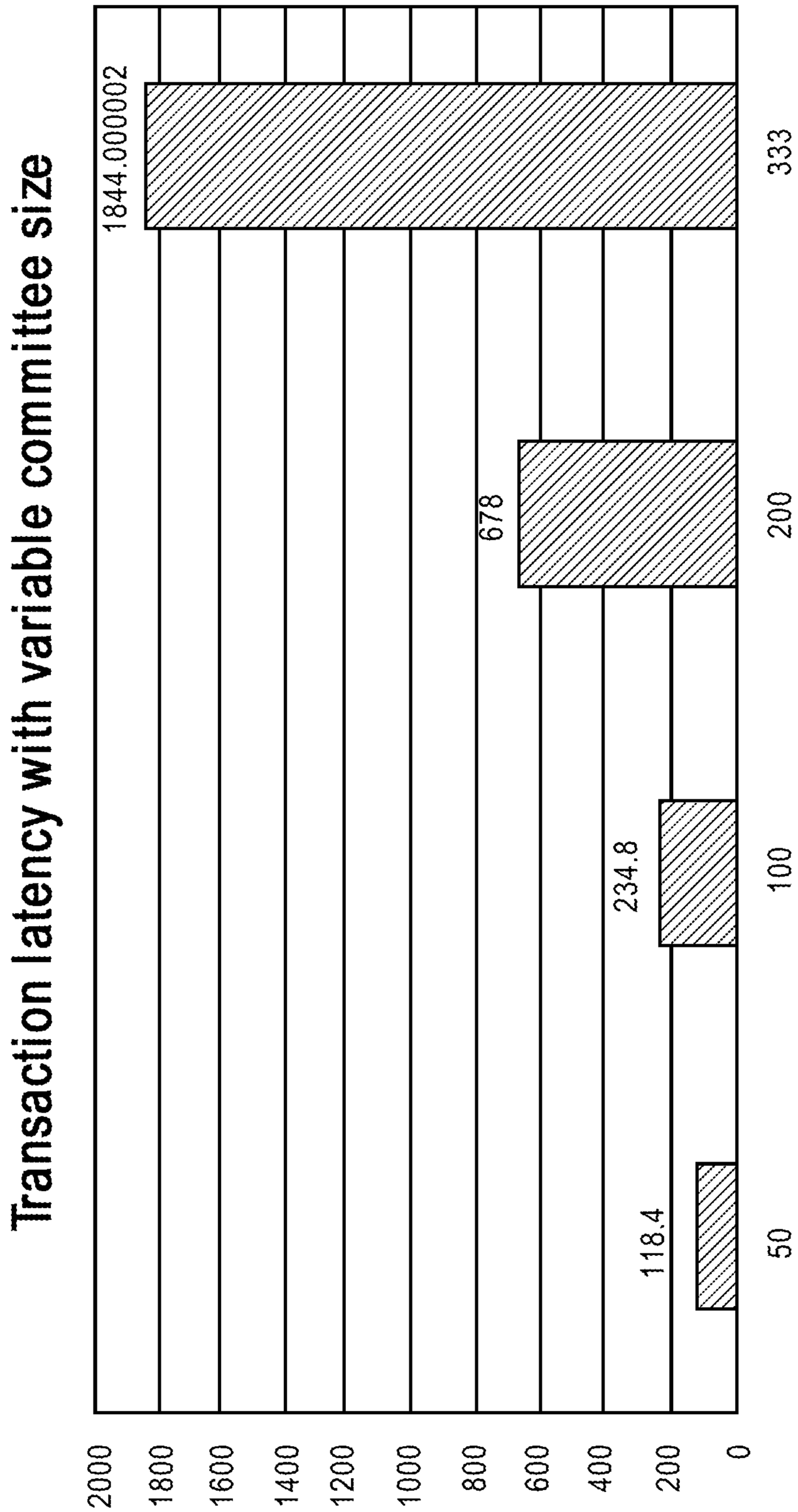

Transaction latency with variable committee size
1844.000002
678
234.8
118.4
333
200
100
50
Number of partties in each committee
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Latency (S)

FIG. 17

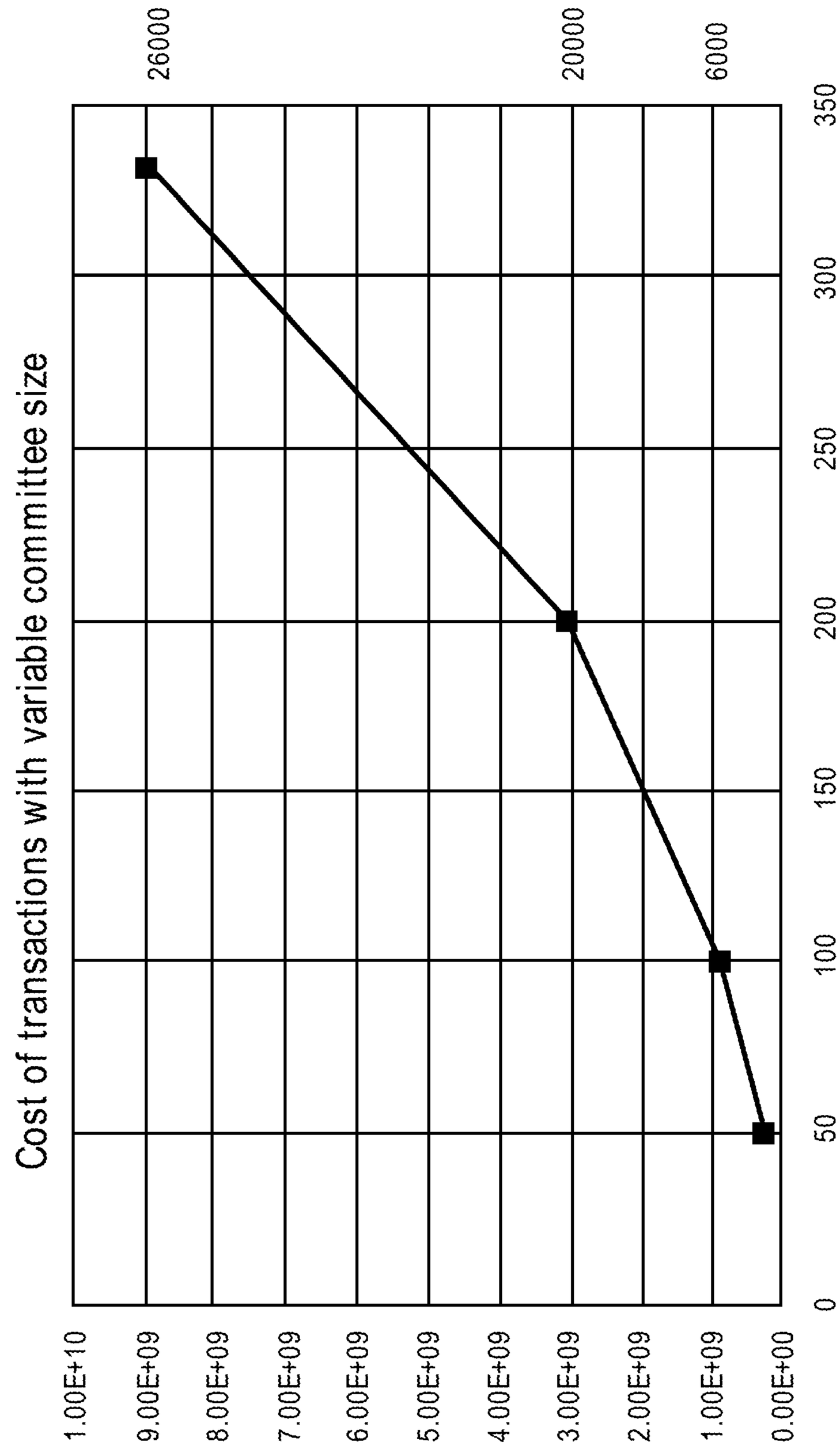

Bandwidth (MB)
26000
20000
6000
0
350
300
250
200
150
100
50
0
Cost of transactions with variable committee size
Number of parties in each committee
1.00E+10
9.00E+09
8.00E+09
7.00E+09
6.00E+09
5.00E+09
4.00E+09
3.00E+09
2.00E+09
1.00E+09
0.00E+00
Number of messages

FIG. 18

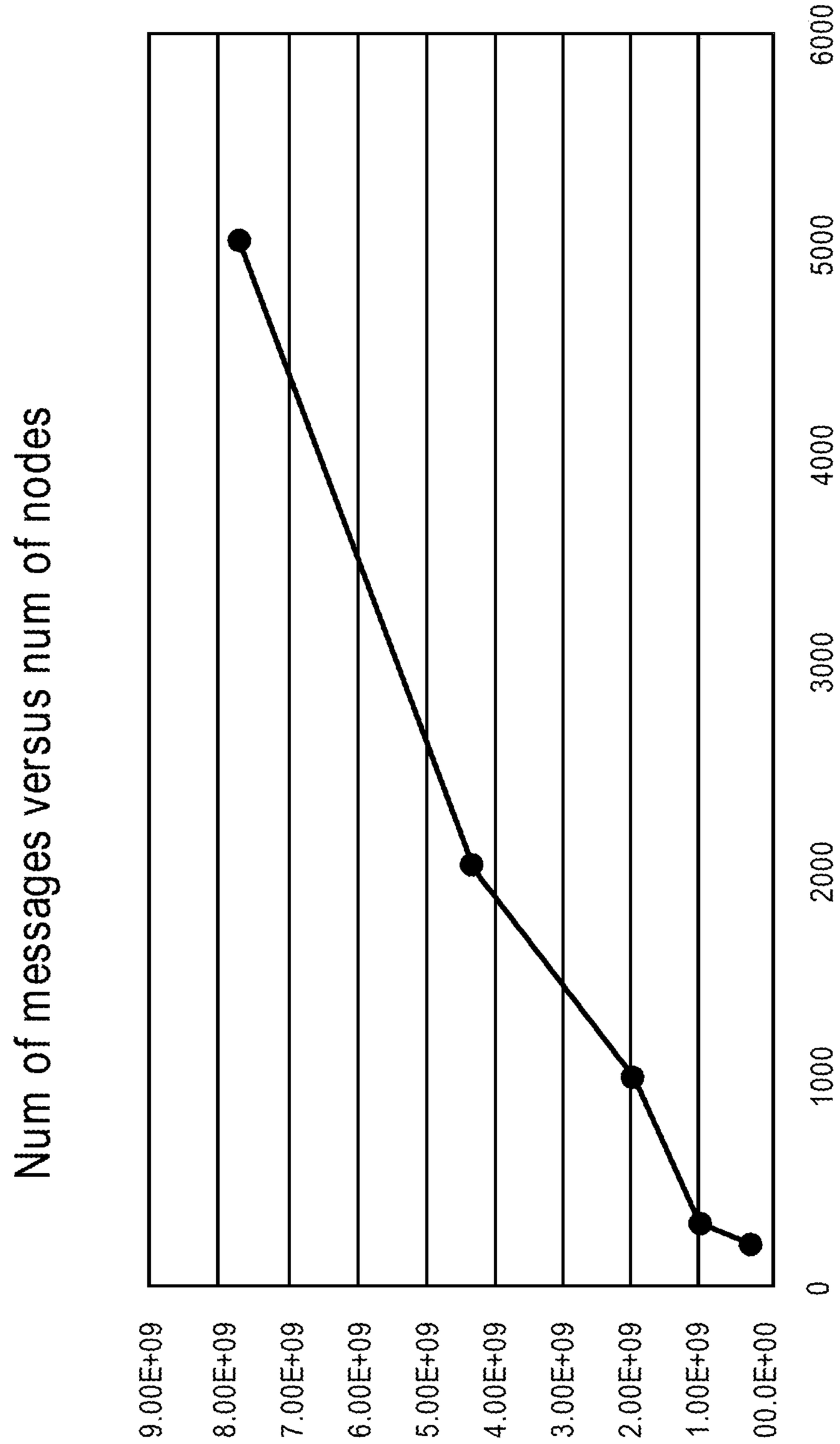

Num of messages versus num of nodes
9.00E+09
8.00E+09
7.00E+09
6.00E+09
5.00E+09
4.00E+09
3.00E+09
2.00E+09
1.00E+09
00.0E+00
Number of messages
3000
4000
5000
6000
0
1000
2000
Number of nodes

FIG. 19

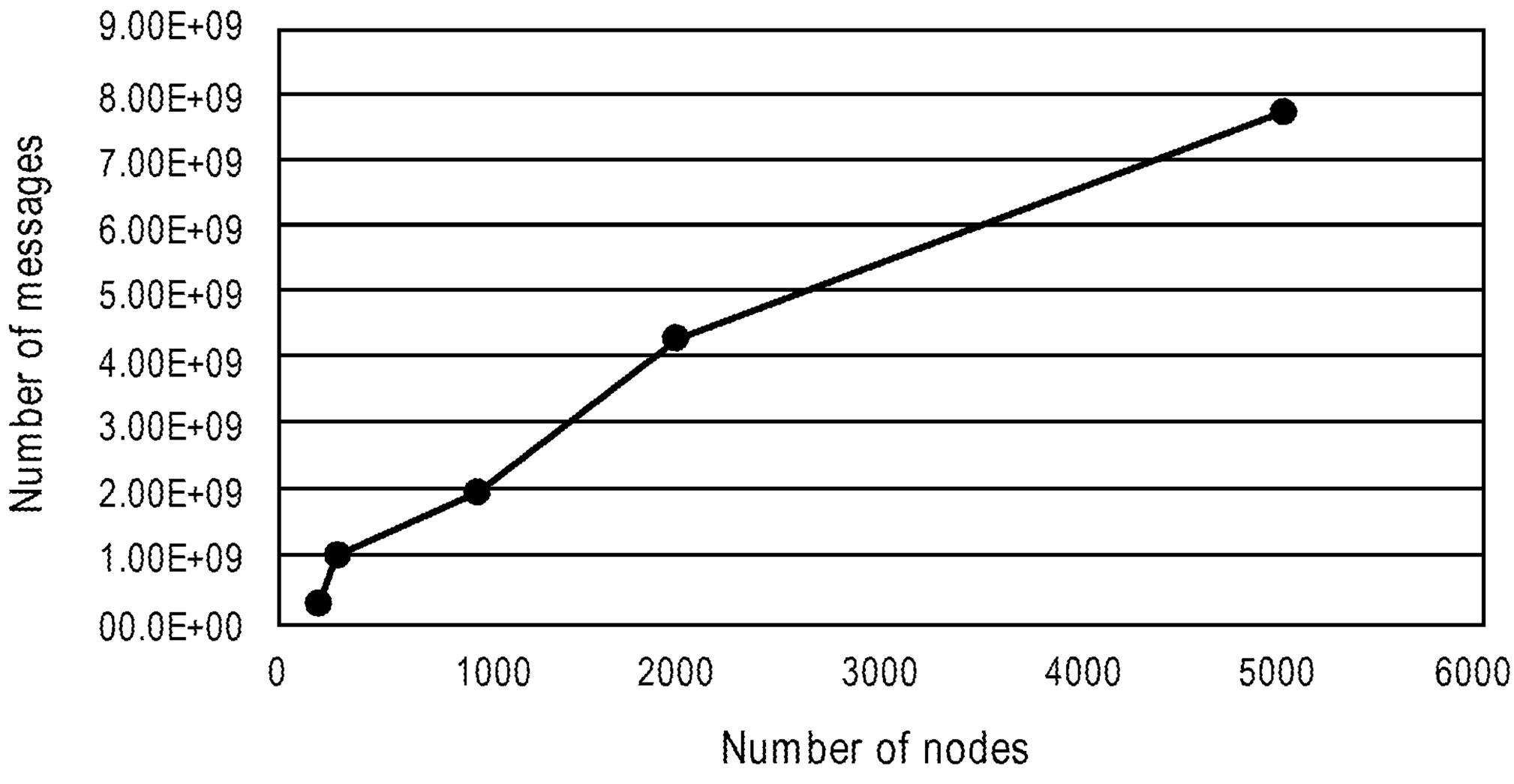

Num of messages versus num of nodes
Number of messages
9.00E+09
8.00E+09
7.00E+09
6.00E+09
5.00E+09
4.00E+09
3.00E+09
2.00E+09
1.00E+09
00.0E+00
0
1000
2000
3000
4000
5000
6000
Number of nodes

FIG. 20

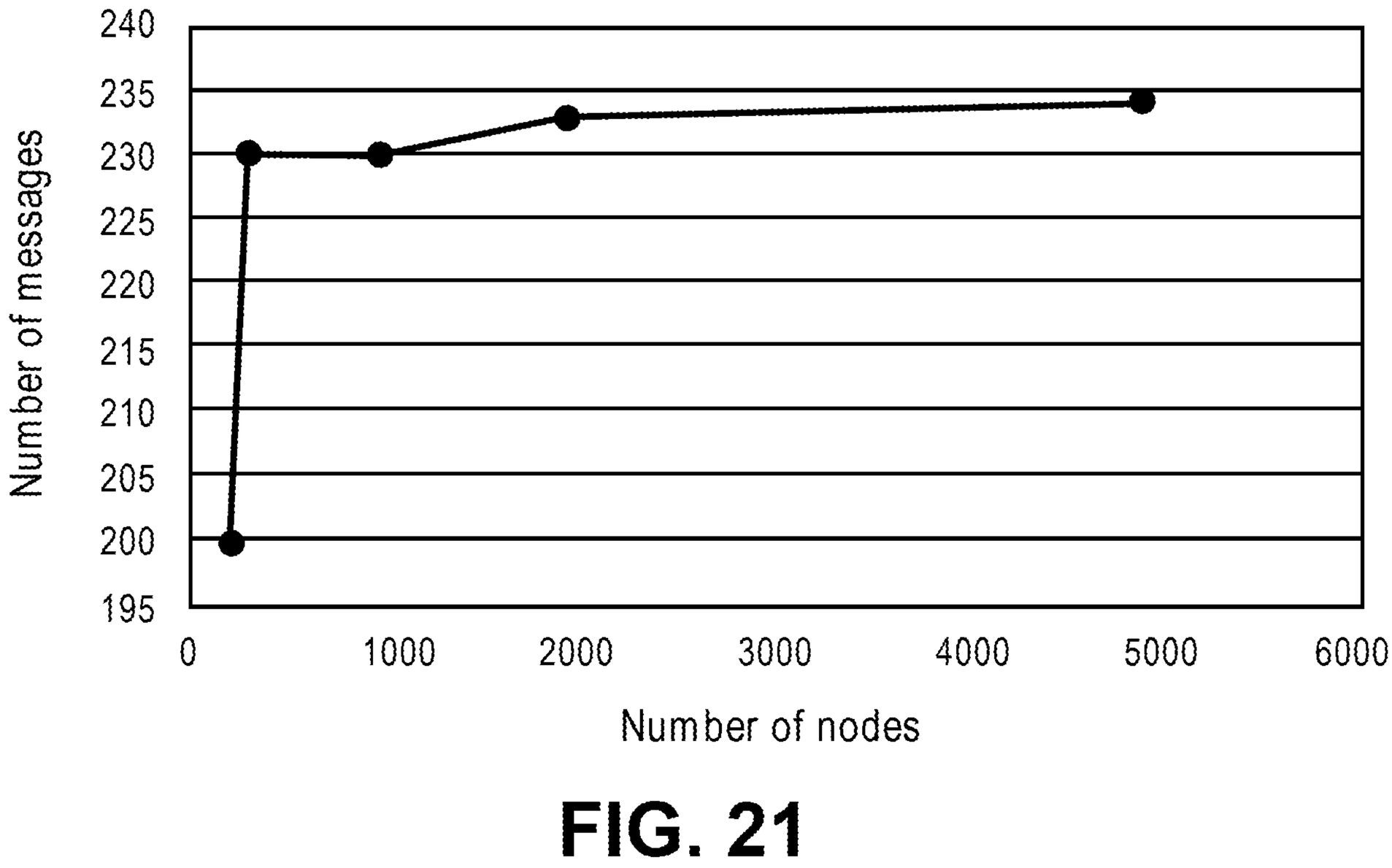

Latency versus num of nodes
Number of messages
240
235
230
225
220
215
210
205
200
195
0
1000
2000
3000
4000
5000
6000
Number of nodes

FIG. 21

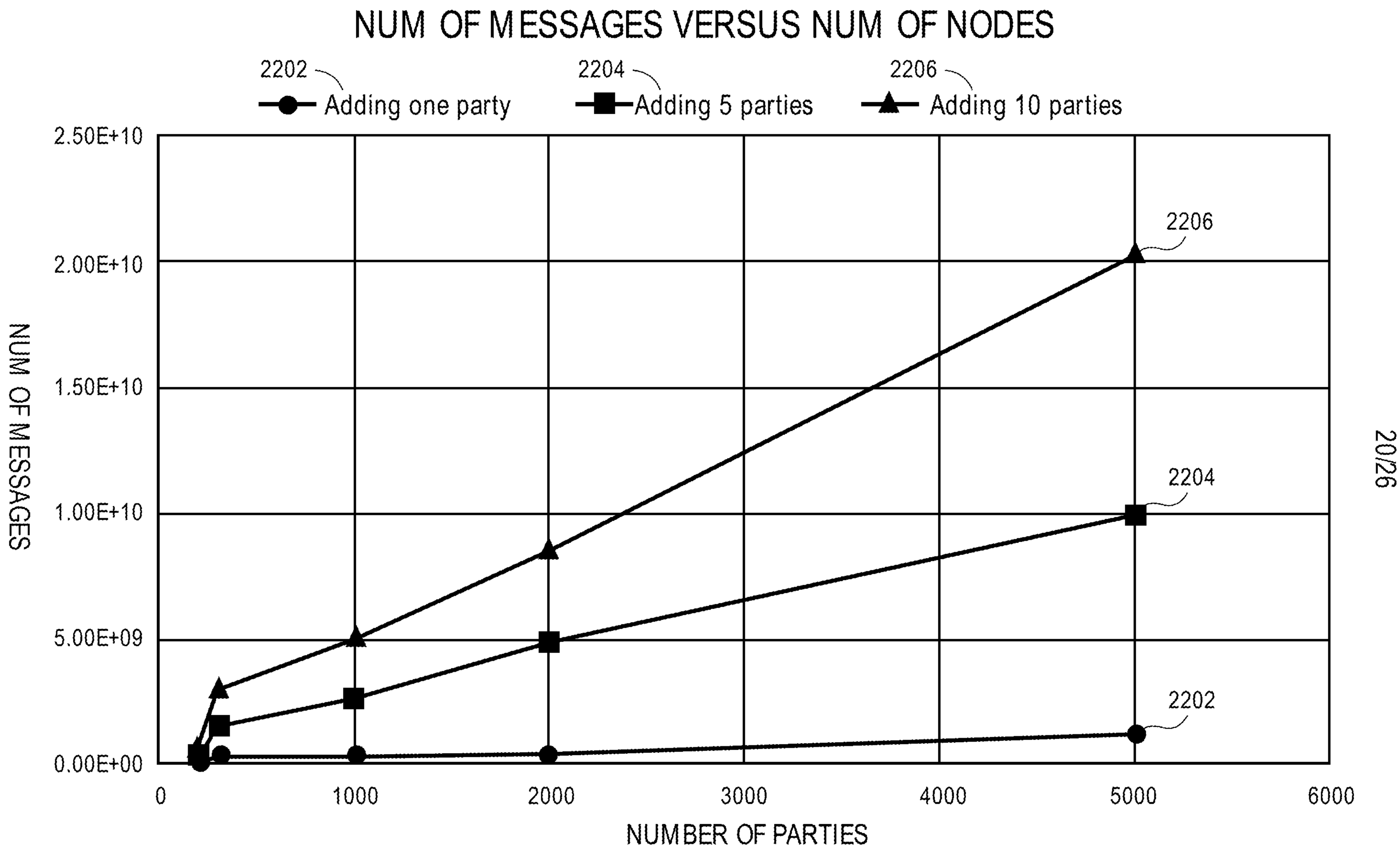

NUM OF MESSAGES VERSUS NUM OF NODES
2202
Adding one party
2204
Adding 5 parties
2206
Adding 10 parties
2.50E+10
2.00E+10
1.50E+10
1.00E+10
5.00E+09
0.00E+00
NUM OF MESSAGES
0
1000
2000
3000
4000
5000
6000
NUMBER OF PARTIES
2206
2204
2202

FIG. 22

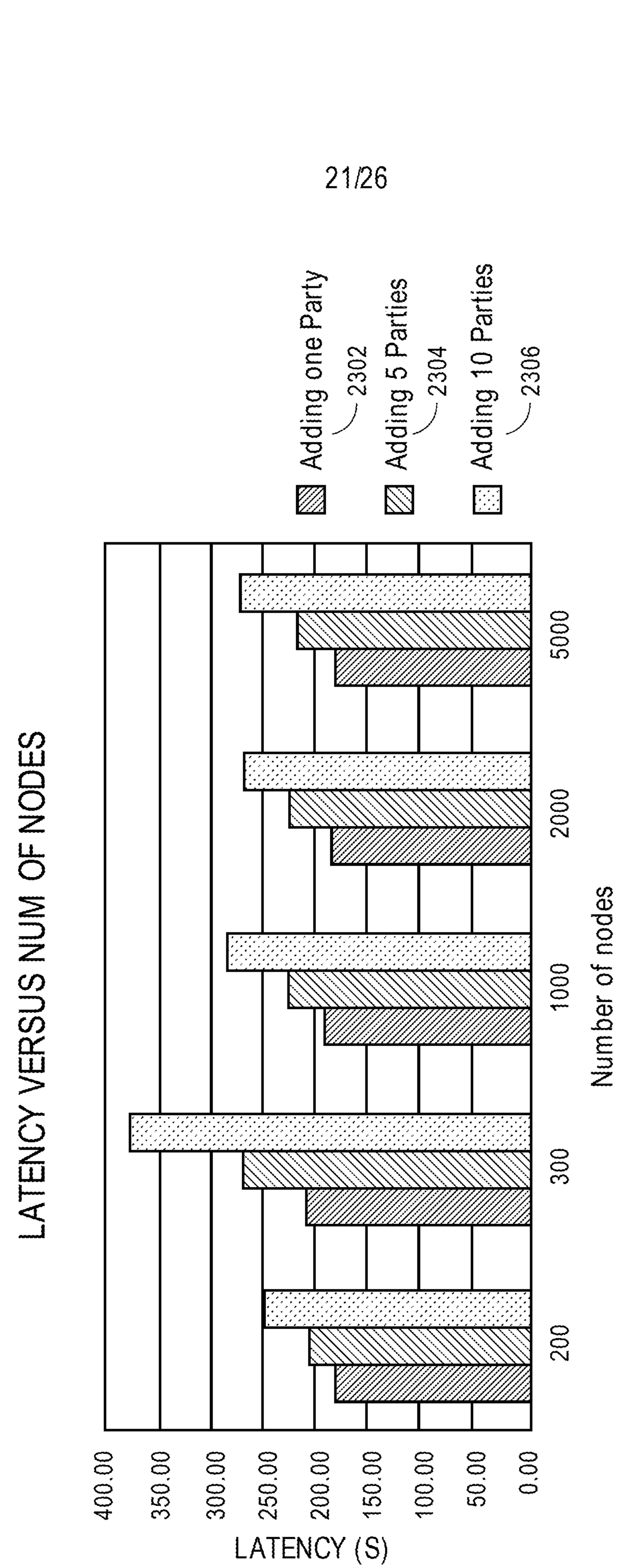

LATENCY VERSUS NUM OF NODES
Adding one Party
2302
Adding 5 Parties
2304
Adding 10 Parties
2306
5000
2000
1000
300
200
Number of nodes
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
LATENCY (S)

FIG. 23

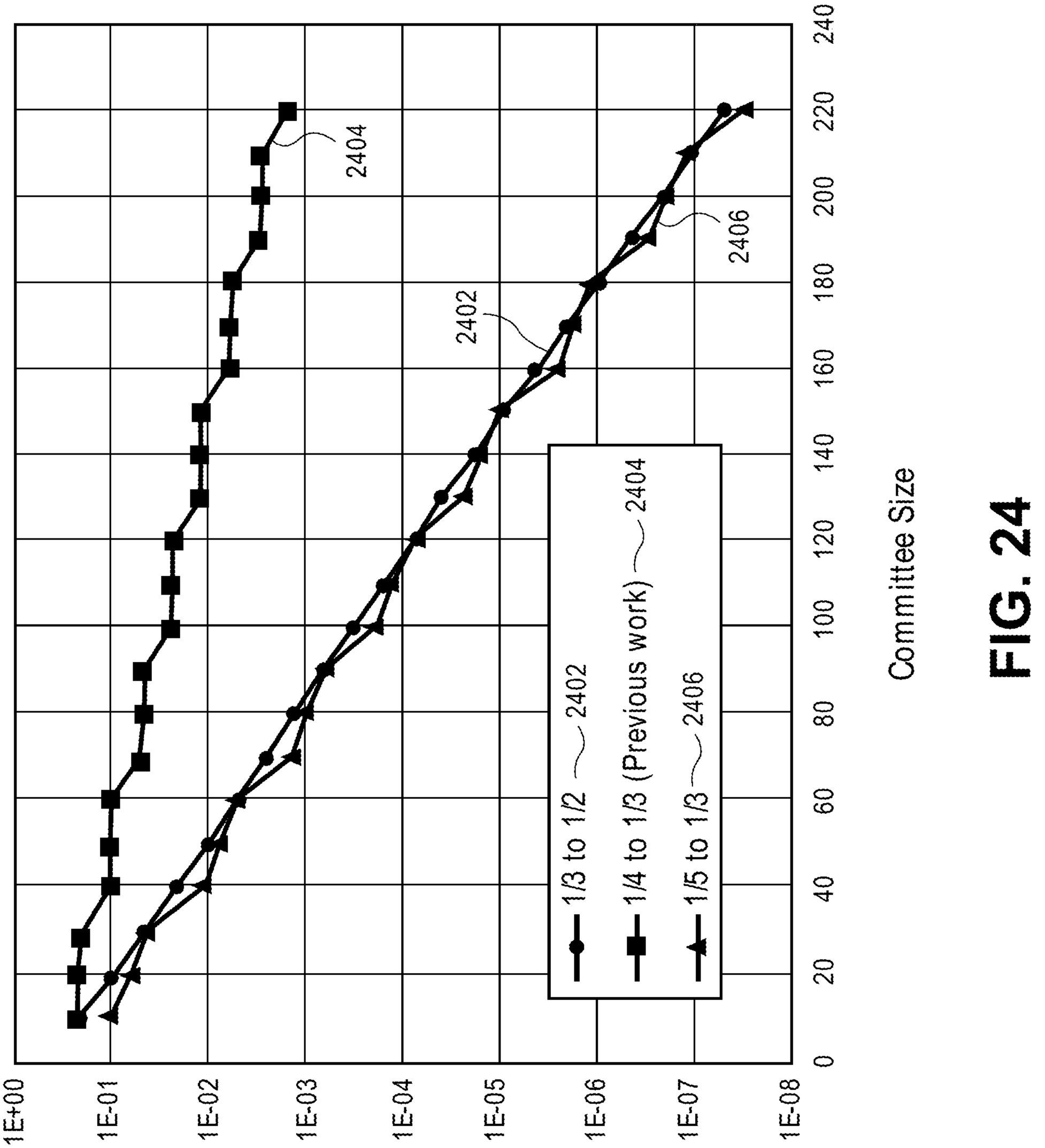

2404
2402
2406
1/3 to 1/2
1/4 to 1/3 (Previous work)
1/5 to 1/3
Committee Size
Failure Probability
0
20
40
60
80
100
120
140
160
180
200
220
240
1E+00
1E-01
1E-02
1E-03
1E-04
1E-05
1E-06
1E-07
1E-08

FIG. 24

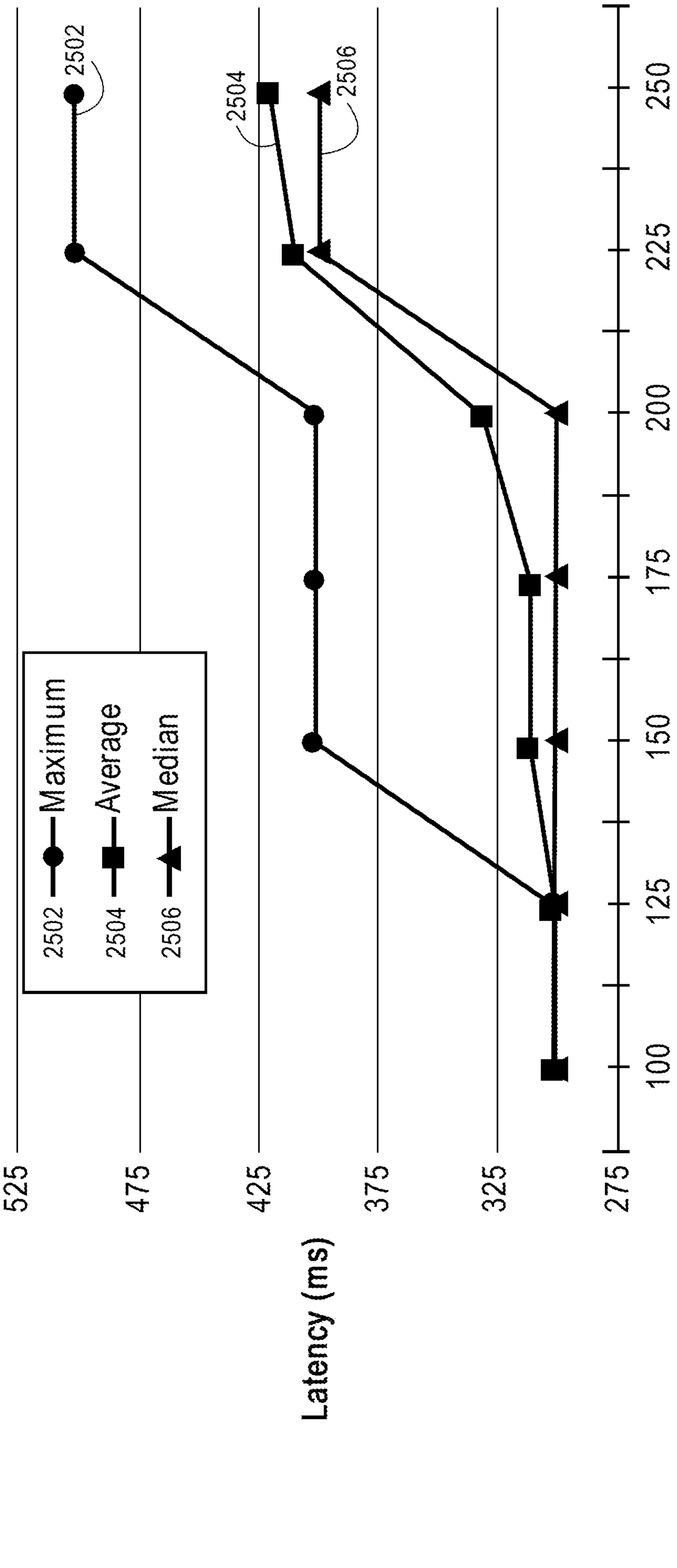

2502
2504
2506
Maximum
Average
Median
525
475
425
375
325
275
Latency (ms)
250
225
200
175
150
125
100
Committee Size

FIG. 25

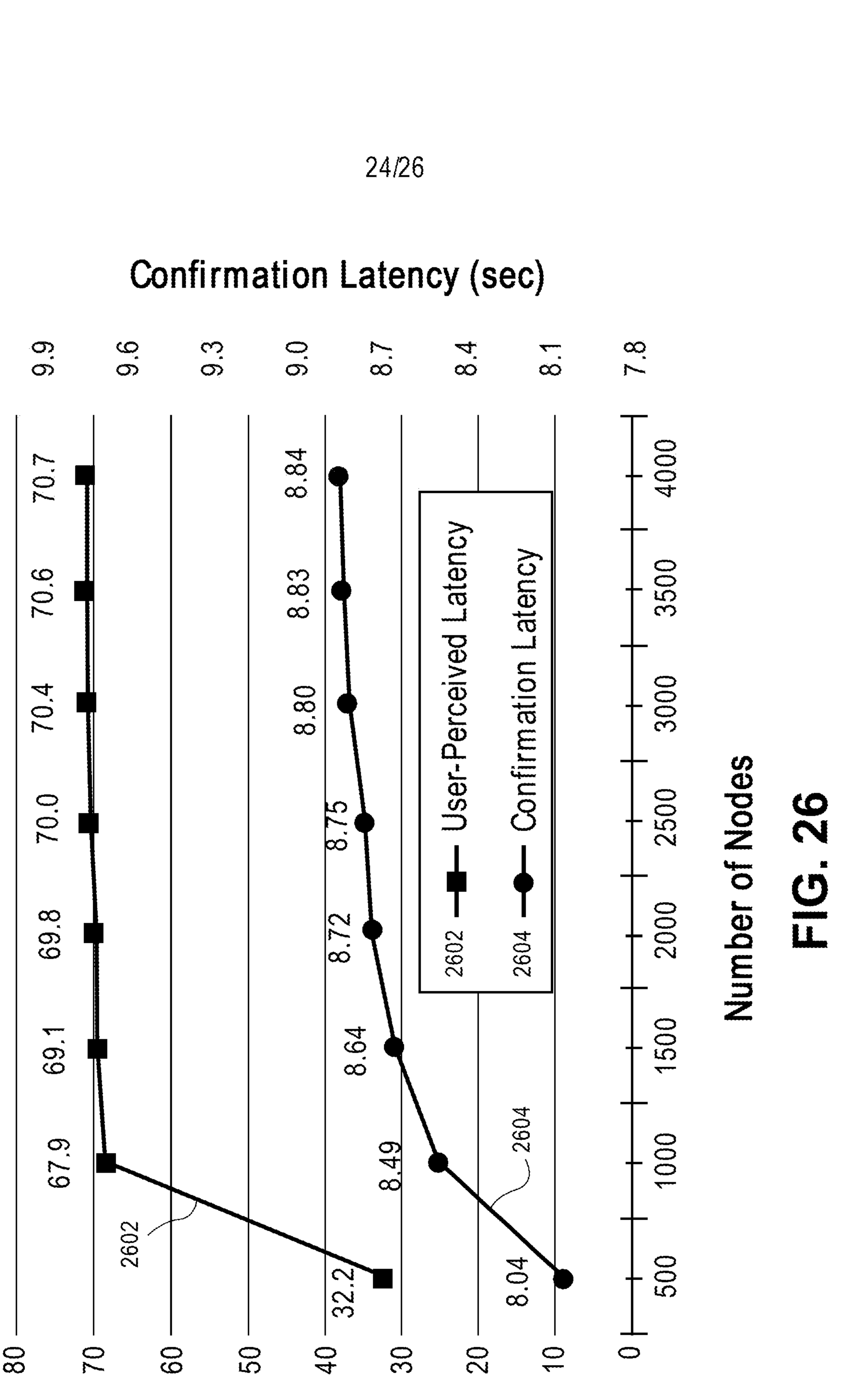

Confirmation Latency (sec)
9.9
9.6
9.3
9.0
8.7
8.4
8.1
7.8
70.0
70.4
70.6
70.7
69.8
69.1
67.9
8.80
8.83
8.84
8.75
8.72
8.64
8.49
32.2
8.04
2602
2604
User-Perceived Latency
Confirmation Latency
2602
2604
500
1000
1500
2000
2500
3000
3500
4000
Number of Nodes
80
70
60
50
40
30
20
10
0
User-Perceived Latency (sec)

FIG. 26

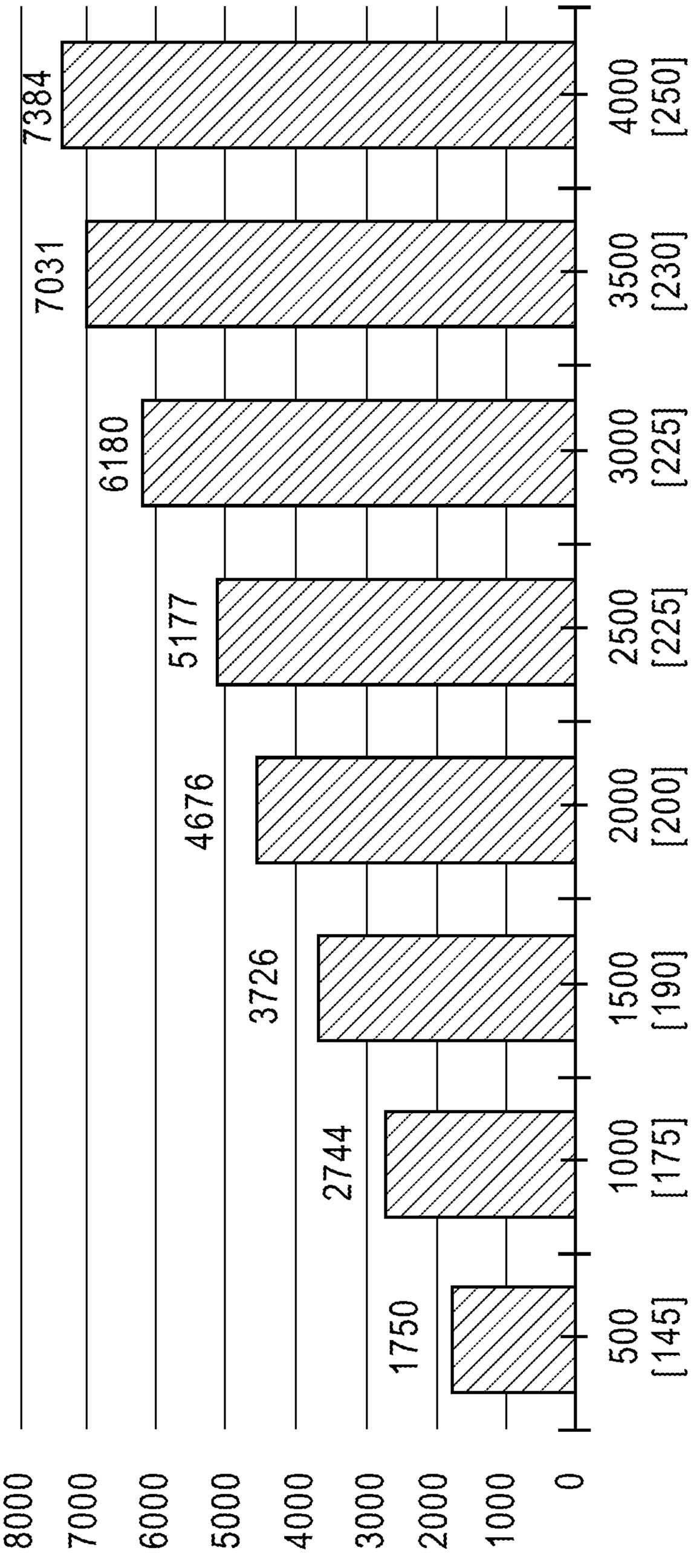

7384
4000
[250]
7031
3500
[230]
6180
3000
[225]
5177
2500
[225]
4676
2000
[200]
3726
1500
[190]
2744
1000
[175]
1750
500
[145]
Number of Nodes
[Committee Size]
8000
7000
6000
5000
4000
3000
2000
1000
0
Transactions per Second

FIG. 27

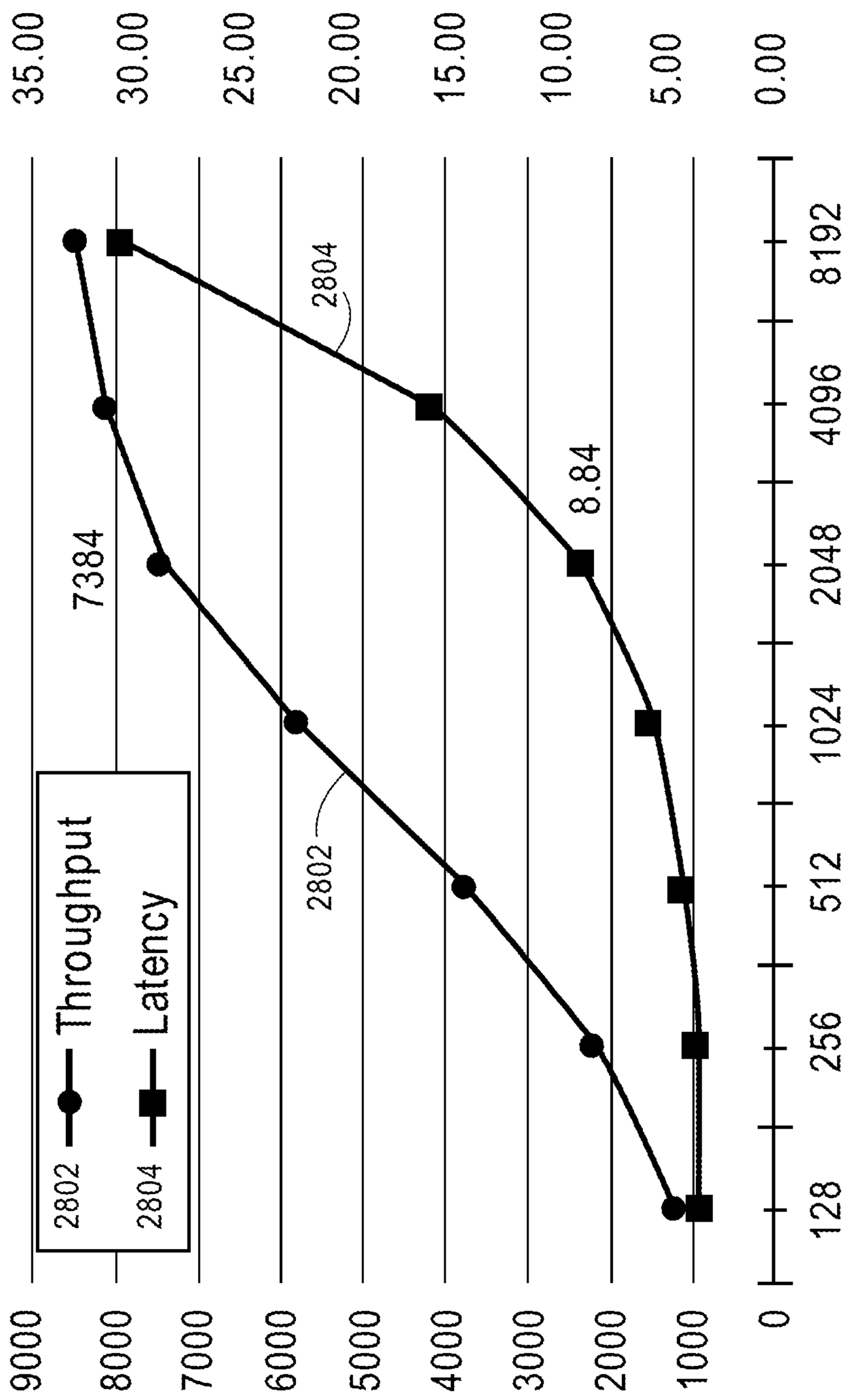

Latency (sec)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
7384
2804
8.84
2802
2048
4096
8192
Block Size (KB)
128
256
512
1024
2802
Throughput
2804
Latency
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Transactions per Second

FIG. 28