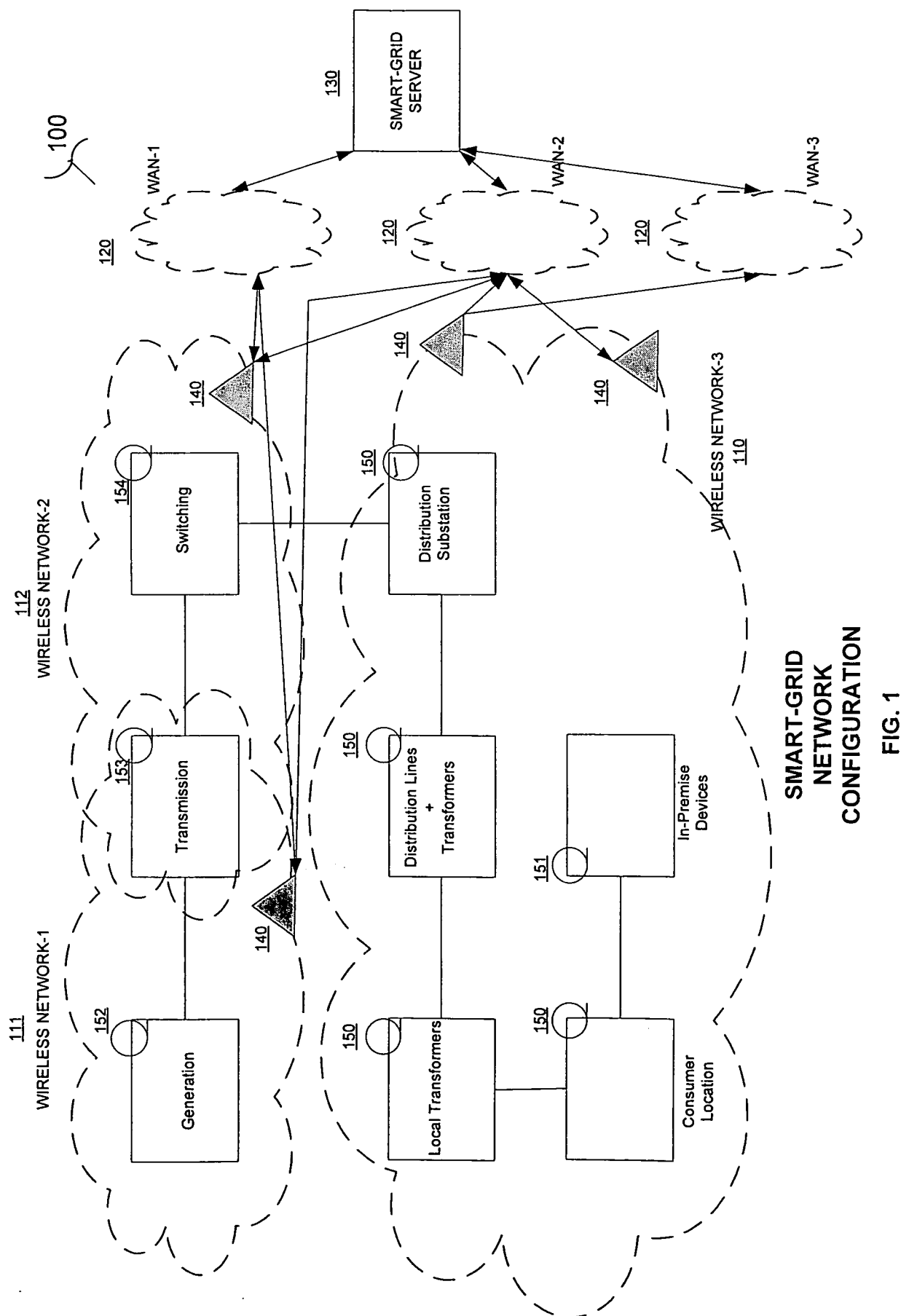


1/22



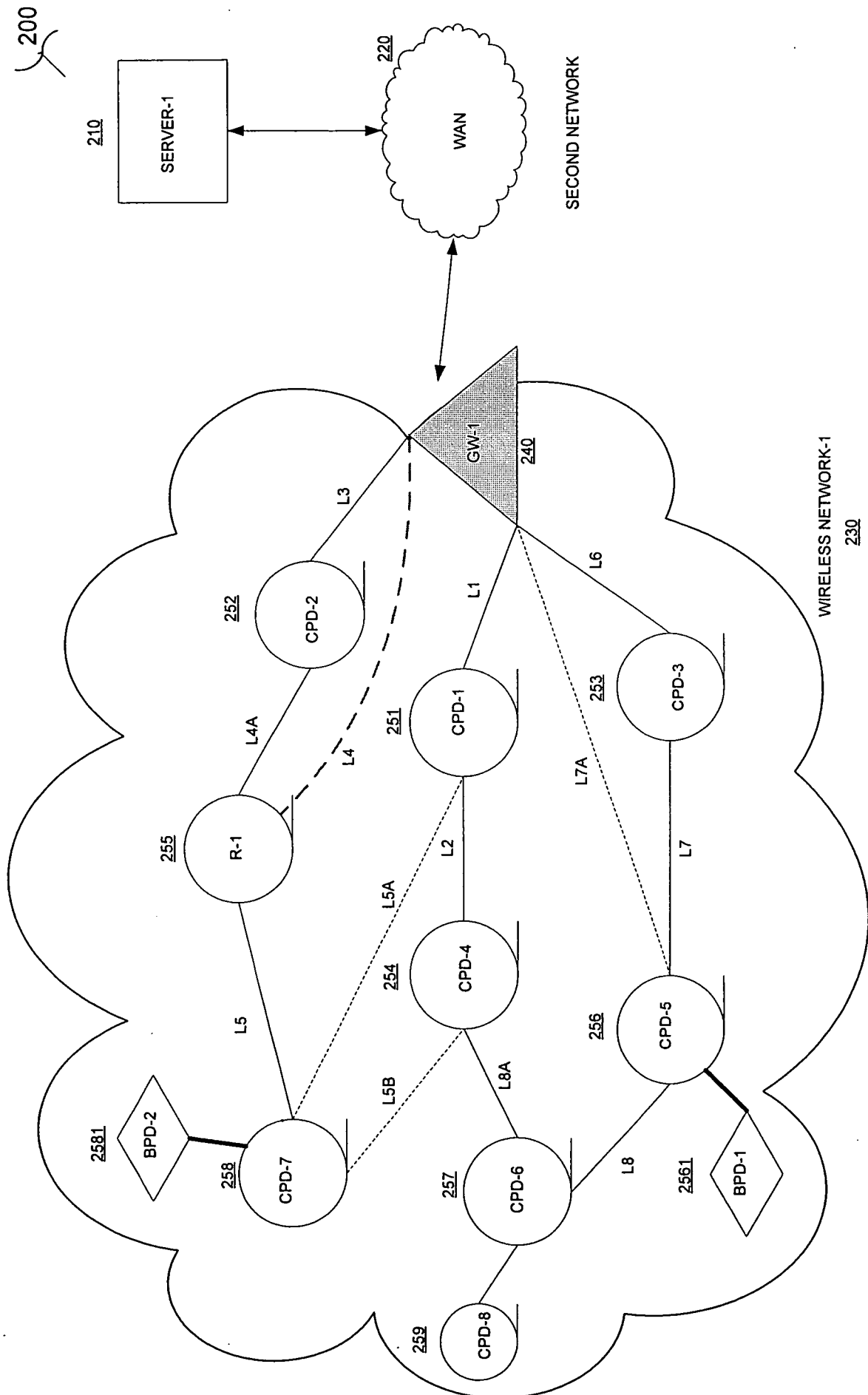


FIG. 2

300

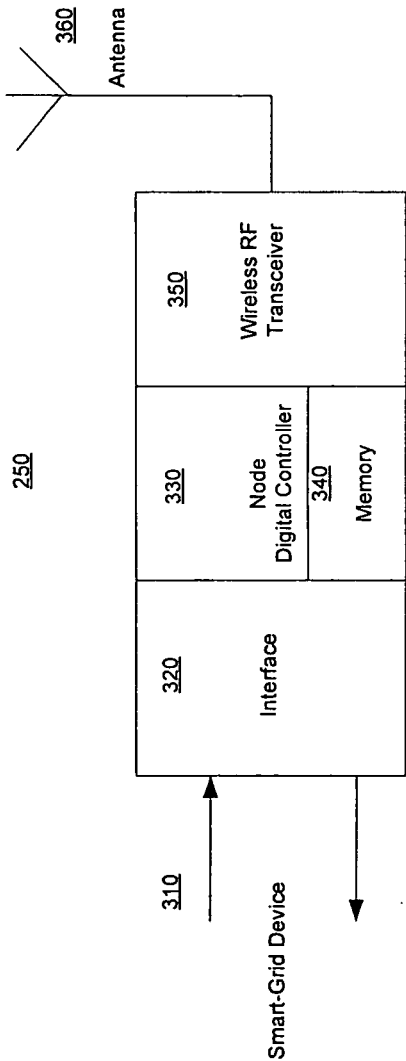


FIG. 3 WIRELESS NETWORK
NODE

400

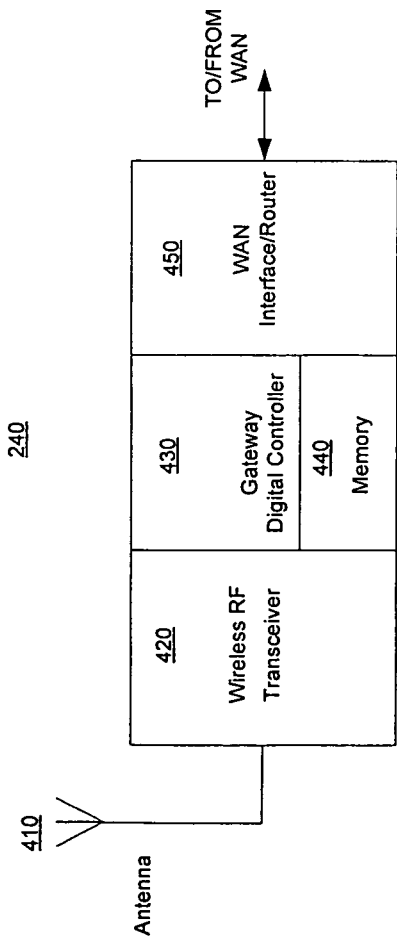


FIG. 4 WIRELESS NETWORK
GATEWAY

4/22

500

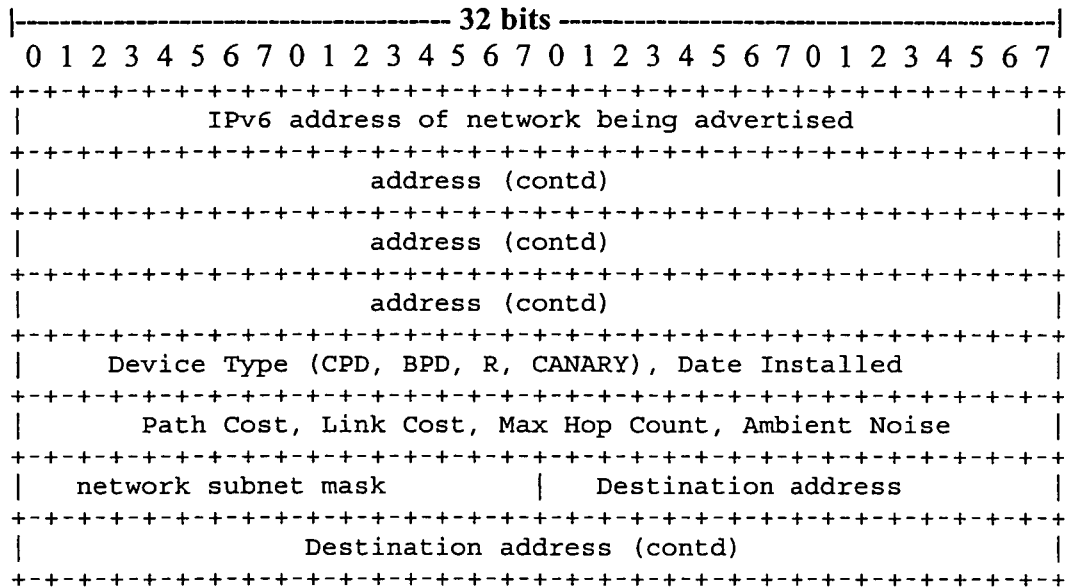


FIG. 5

NETWORK ADVERTISEMENT MESSAGE FORMAT

5/22

600



```
Network1] →
[Destination Address → ]
[ROUTE INFO TIME STAMP]
[Egress Node → GATEWAY ID]
[(Node1) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
[(Node2) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
[      ....      ]
[(NodeN) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
[Network2] →
[Destination Address → ]
[ROUTE INFO TIME STAMP]
[Egress Node → GATEWAY ID]
[(Node1) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
[(Node2) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
[      ....      ]
[(NodeN) (flag) (Link Cost) (Path Cost) (Type/Address) (Quality) ]
```

FIG. 6

ROUTING TABLE EXAMPLE

6/22

700

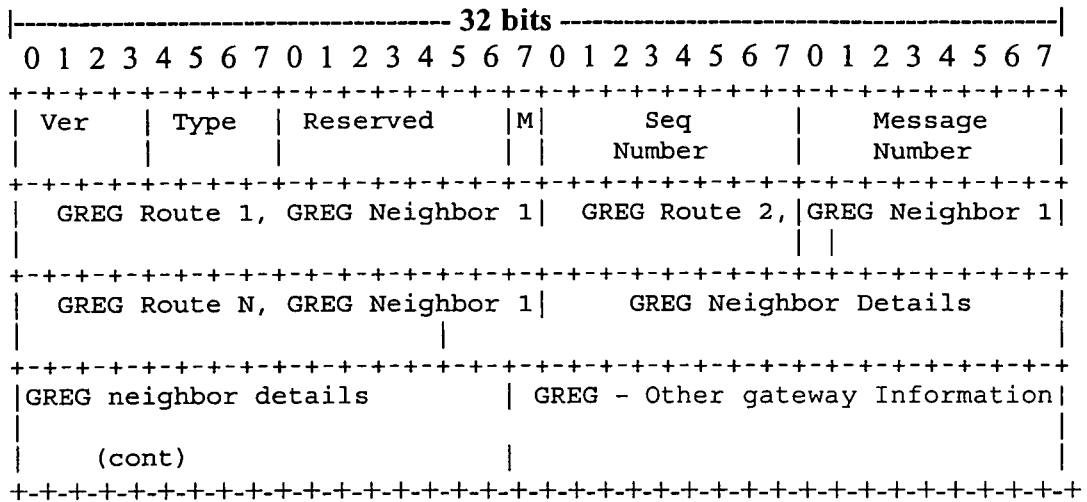
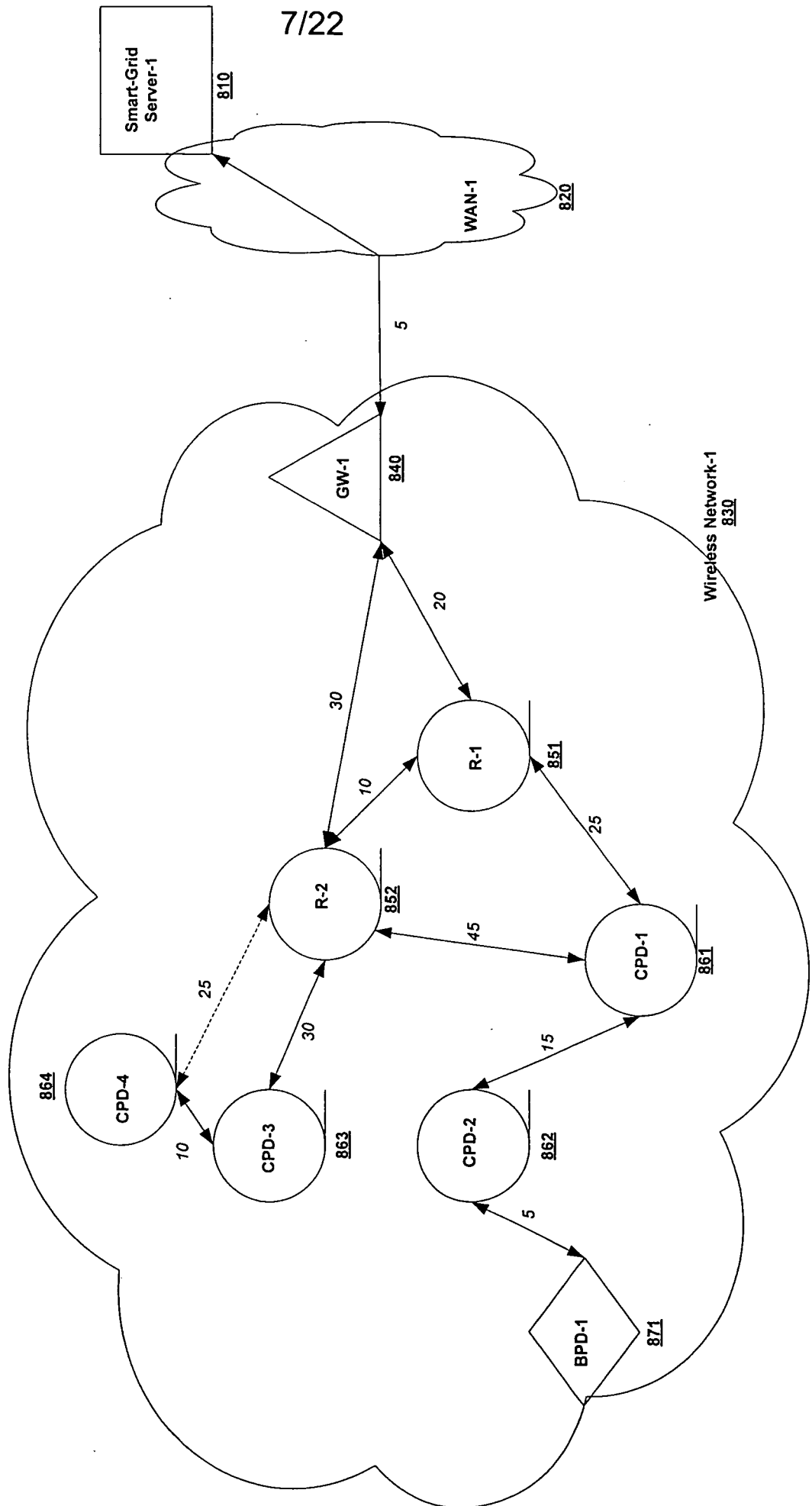


FIG. 7

FORMAT OF SOURCE REGISTRATION
MESSAGE WITH GATEWAY

FIG. 8
Example of Route Discovery by Nodes
In a Smart-Grid Network



800

8/22

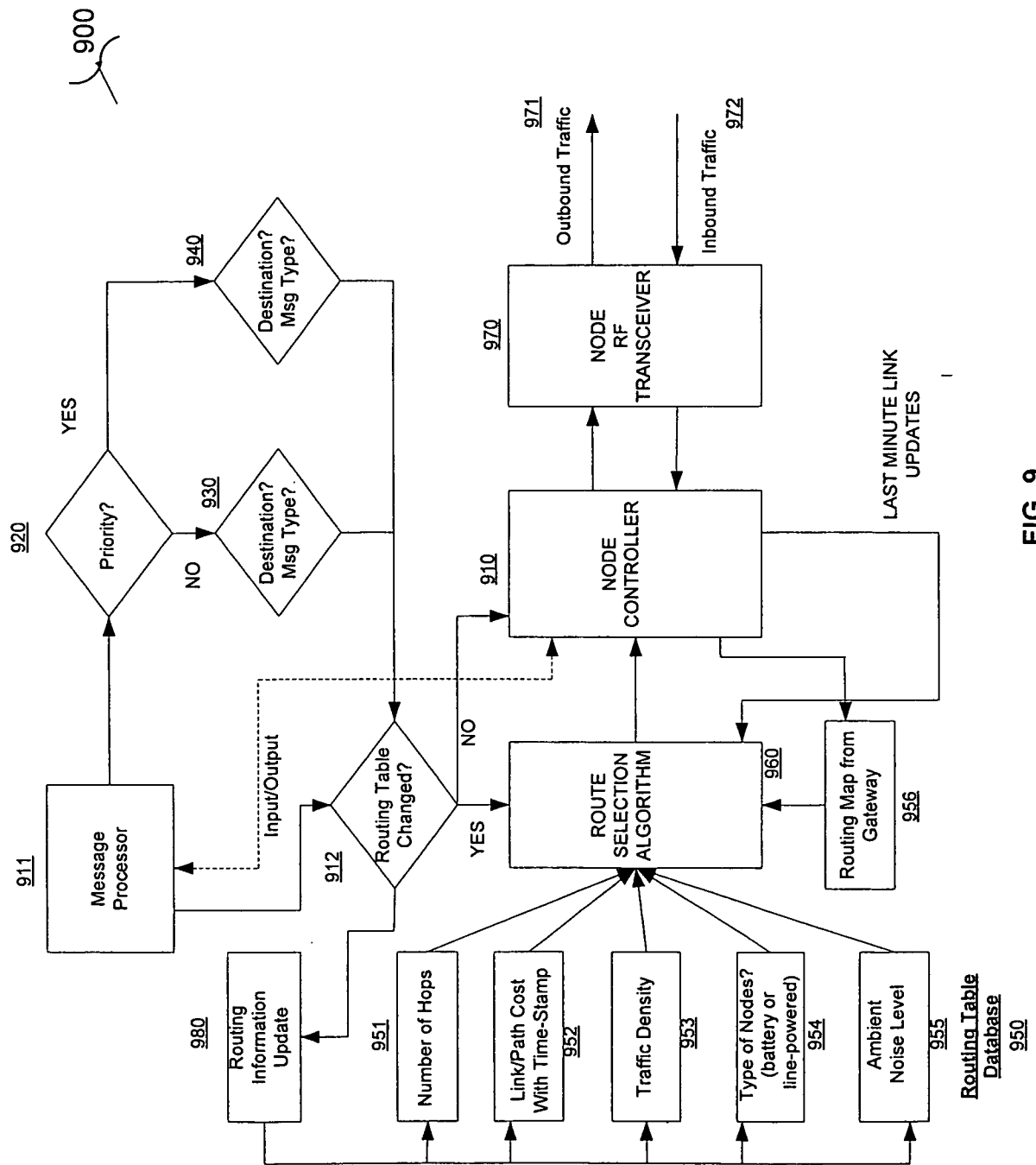
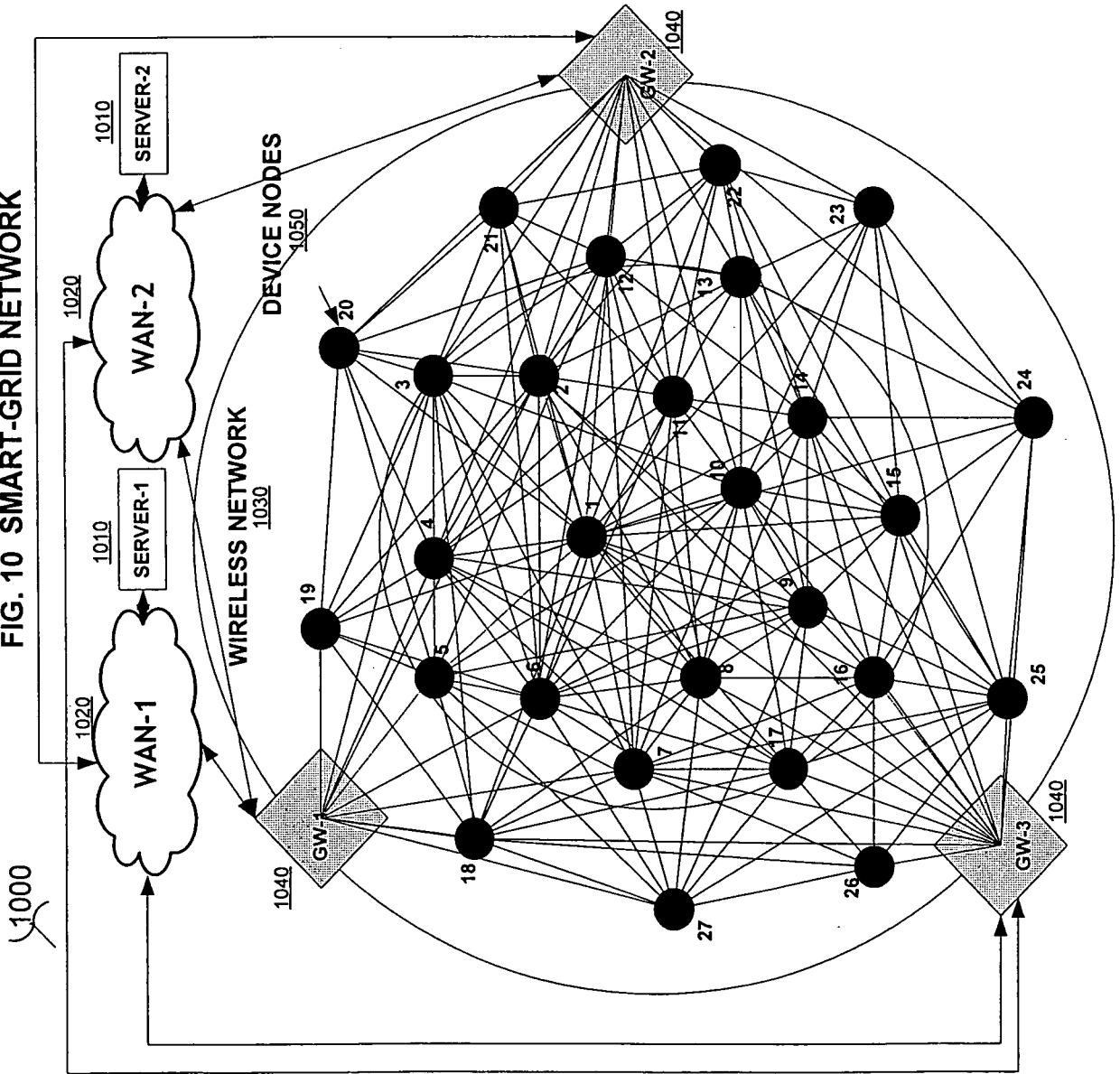


FIG. 9
ROUTE SELECTION PROCESS

9/22

FIG. 10 SMART-GRID NETWORK



10/22

1100

NODE	POSSIBLE ROUTES TO GATEWAYS
1	1>5>GW1; 1>4>GW1; 1>19>GW1; 1>6>GW1; 1>6>18>GW1; 1>4>19>GW1; 1>5>19>GW1; 1>6>5>GW1; 1>12>GW2; 1>2>GW2; 1>22>GW2; 1>11>GW2; 1>11>12>GW2; 2>12>GW2; 1>2>21>GW2 1>16>GW-3; 1>9>16>GW3; 1>9>25>GW3
2	2>5>GW1; 2>4>GW1; 2>119>GW12>16>GW1; 2>1>(all 1>GW1 routes); 2>GW2; 2>12>GW2; 2>21>GW2; 2>22>GW2; 2>13>GW2; 2>GW3 (unstable); 2>9>25>GW3; 2>9>16>GW3; 2>8>GW3; 2>8>17>GW3;
3	3>GW1 (unstable); 3>19>GW1; 3>4>GW1; 3>5>GW1; 3>5>18>GW1; 3>5>19>GW1; 3>GW2 (long-hop); 3>12>GW2; 3>21>GW2; 3>2>GW2; 3>1 (all 1>GW3 multi-hops); 3>(all 9>GW3 multi-hops);
4	4>GW1; 4>19>GW1; 4>5>GW1; 4>5>18>GW1; 4>GW2 (long-hop); 4>2>GW2; 4>3>GW2; 4>3>21>GW2; 4>8>GW3; 4>17>GW3; 4>8>16>GW3; 4>9>25>GW3;
5	5>GW1; 5>18>GW1; 5>19>GW1; 5>6>GW1; 5>4>GW1; 5>(all 4>GW2 routes); 5>1 (all 1>GW2 routes); 5>2>GW2; 5>6>17>GW3; 5>7>GW3; 5>27>26>GW3;
6	6>GW1; 6>5>GW1; 6>18>GW16>7>GW1; 6>(all 1>GW2 routes); 6>2>GW2; 6>4>GW2 (long-hop); 6>12>GW2; 6>3>GW2; 6>21>GW2; 6>17>GW3; 6>7>GW3; 6>7>17>GW3; 6>8>GW3; 6>8>16>GW3; 6>8>9>25>GW3;
7	7>GW1; 7>18>GW1; 7>6>GW1; 7>5>GW1; 7>(all 1>GW2 routes); 7>11>GW2; 7>12>GW2 (long-hop); 7>11>12>GW2; 7>GW3; 7>17>GW3; 7>26>GW3; 7>17>25>GW3; 7>16>GW3; 7>16>25>GW3;
8	8>6>GW1; 8>7>GW1; 8>18>GW1; 8>7>18>GW1; 8>(all 1>GW1 routes); 8>(all 1>GW2 routes); 8>11>GW2; 8>12>GW2; 8>2>GW2; 8>2>12>GW2; 8>GW3; 8>16>GW3; 8>17>GW3; 8>9>16>GW3; 8>17>16>GW3; 8>17>26>GW3;
9	9>6>GW1; 9>(all 1>GW1 routes); 9>8>18>GW1; 9>5>GW1; 9>8>6>GW1; 9>13>GW2; 9>10>GW2; 9>10>11>GW2; 9>10>13>GW2; 9>10>11>12>GW2; 9>16>GW3; 9>25>GW3; 9>16>25>GW3; 9>17>GW3; 9>17>26>GW3;
10	10>6>GW1; 10>(all 1>GW1 routes); 10>5>GW1; 10>GW2; 10>11>GW2; 10>11>12>GW2; 10>13>GW2; 10>13>22>GW2; 10>13>12>GW2; 10>25>GW3; 10>15>GW3; 10>16>GW3; 10>9>16>GW3; 10>15>25>GW3; 10>17>GW3;
11	11>(all 1>GW1 routes); 11>4>GW1; 11>7>GW1; 11>2>4>GW1; 11>2>5>GW1; 11>6>18>GW1; 11>GW2; 11>12>GW2; 11>13>GW2; 11>22>GW2; 11>13>22>GW2; 11>14>GW3; 11>14>15>GW3; 11>15>GW3; 11>15>25>GW3; 11>10>25>GW3; 11>10>9>16>GW3;
12	12>(all 1>GW1 routes); 12>3>GW1; 12>2>4>GW1; 12>3>19>GW1; 12>20>19>GW1; 12>GW2; 12>22>GW2; 12>21>GW2; 12>14>GW3; 12>14>16>GW3; 12>13>9>25>GW3; 12>13>9>16>GW3;
13	13>2>5>GW1; 13>4>GW1; 13>4>5>GW1; 13>4>19>GW1; 13>GW2; 13>12>GW2; 13>22>GW2; 13>24>25>GW3; 13>15>25>GW3; 13>14>GW3 (long-hop); 13>14>16>GW3; 13>9>25>GW3;
14	14>(all 1>GW1 routes); 14>10>6>GW1; 14>10>5>GW1; 14>11>4>GW1; 14>11>4>19>GW1; 14>12>GW2; 14>13>GW2; 14>13>22>GW2; 14>23>GW2; 14>23>22>GW2; 14>24>25>GW3; 14>15>GW3; 14>15>25>GW3; 14>16>GW3; 14>9>16>GW3;
15	15>(all 1>GW1 routes); 15>9>5>GW1; 15>9>6>GW1; 15>6>GW1; 15>23>GW2; 15>22>GW2; 15>13>GW2; 15>14>13>GW2; 15>14>13>12>GW2; 15>GW3; 15>25>GW3; 15>16>GW3;
16	16>(all 1>GW1 routes); 16>7>GW1; 16>7>18>GW1; 16>7>5>GW1; 16>15>22>GW2; 16>15>23>GW216>14>22>GW2; 16>14>13>GW2; 16>14>12>GW2; 16>GW3; 16>25>GW3; 16>26>GW3;

FIG. 11A

11/22

NODE	POSSIBLE ROUTES TO GATEWAYS
17	17>18>GW1; 17>7>GW1; 17>6>GW1; 17>7>18>GW1; 17>27>GW1; 17>27>18>GW1; 17>10>GW2; 17>10>13>GW2; 17>9>13>GW2; 17>9>14>13>GW2; 17>9>14>12>GW2; 17.GW3; 17>26>GW3; 17>25>GW3;
18	18>GW1; 18>5>GW1; 18>6>GW1; Has no practical links to GW2; 18>26>GW3; 18>GW3 (very long-hop); 18>17>GW3; 18>27>26>GW3;
19	19>GW1; 19>5.GW1; 19>18>GW1; 19>20>GW2 (long-hop); 19>20>21>GW2; 19>3>21>GW2; 19>2>GW2; Has no practical links to GW3;
20	20>19>GW1; 20>5>GW1; 20>4>GW1; 20>3>GW1; 20>3>4>GW1; 20>GW2 (long-hop); 20>21>GW2; 20>3>GW2; 20>3>12>GW2; Has no practical links to GW3;
21	21>3>GW1; 21>4>GW1; 21>4>5>GW1; 21>3>19>GW1; 21>4>19>GW1; 21>GW2; 21>12>GW2; 21>22> GW2; Has no practical links to GW3;
22	22> (all 1>GW1 routes); 22>11>1 (all 1>GW1 routes); 22>11>6>GW1; 22>GW2; 22>12>GW2; 22>15>GW3; 22>15>25>GW3; 22>15>16>GW3; 22>14>16>GW3;
23	23>1 (all 1>GW1 routes) but long-hops; 23>10>5>GW1; 23>10>6>GW1; 23>GW2; 23>22>GW2; 23>13>GW2; 23>15>GW3; 23>15>25>GW3; 23>24>25>GW3; 23>25>GW3;
24	No practical links to GW1; 24>23>GW2; 24>22.GW2; 24>13>GW2; 24>13>12>GW2; 24>25>GW3; 24>16>GW3; 24>15>GW3; 24>15>16>GW3;
25	25>17>18>GW1; 25>7>GW1 (long-hops); 25>17>7>GW1; 25>23>GW2; 25>15>22.GW2; 25>24>22>GW2; 25>24>13.GW2; 25>GW3; 25>16>GW3; 25>26>GW3;
26	26>18>GW1; 26>27>18>GW1; 26>27>GW1; 26>17>7>GW1; No practical links to GW2; 26>GW3; 26>25>GW3; 26>16>GW3;
27	27>GW1 (long-hop); 27>18>GW1; 27>6>GW1; 27>5>GW1; 27>17>GW1; No practical links to GW2; 27>26>GW3; 27>17>GW3; 27>25>GW3; 27>17>16>GW3;

FIG. 11B

FIG. 11A
FIG. 11B
FIG. 11

12/22

FIG. 12
NODES & PREFERRED GATEWAYS FOR EGRESS

 1200

NODE	PREFERRED GATEWAYS
	LISTED IN THE ORDER OF PREFERENCE OR REACHABILITY
1	GW1, GW2, GW3
2	GW2, GW1, GW3
3	GW1, GW2, GW3
4	GW1, GW2, GW3
5	GW1, GW2, GW3
6	GW1, GW3, GW2
7	GW1, GW3, GW2
8	GW3, GW1, GW2
9	GW3, GW1, GW2
10	GW2, GW3, GW1
11	GW2, GW1, GW3
12	GW2, GW1, GW3
13	GW2, GW3, GW1
14	GW2, GW3, GW1
15	GW3, GW2, GW1
16	GW3, GW2, GW1
17	GW3, GW1, GW2
18	GW1, GW3, (GW2)
19	GW1, GW2, (GW3)
20	GW1, GW2, (GW3)
21	GW2, GW1, (GW3)
22	GW2, GW3, (GW1)
23	GW2, GW3, (GW1)
24	GW3, GW2, (GW1)
25	GW3, GW2, (GW1)
26	GW3, GW1, (GW2)
27	GW3, GW1, (GW2)

13/22

FIG. 13
NODE 1
ROUTE OPTIMIZATION

 1300

Node 1:
Preferred Gateway: GW1

Routing Scenarios:

To GW1:

Possible Routes: 1>5>GW1; 1>4>GW1; 1>19>GW1; 1>6>GW1; 1>6>18>GW1; 1>4>19>GW1; 1>5>19>GW1;
1>6>5>GW1;

Routes via Initial Discovery: 1>4>19>GW1; 1>6>18>GW1;

Routes via Optimization 1: 1>5>GW1; 1>4>GW1; 1>6>GW1;

Route via Optimization 2: 1>5>GW1;

To GW2:

Possible Routes: 1>12>GW2; 1>2>GW2; 1>22>GW2; 1>11>GW2; 1>11>12>GW2; 2>12>GW2; 1>2>21>GW2;

Optimized Route: 1>12>GW2;

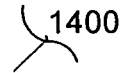
To GW3:

Routes via Initial Discovery: 1>16>GW-3; 1>9>16>GW3; 1>9>25>GW3;

Optimized Route: 1>9>16>GW3

14/22

FIG. 14
NODE 11
ROUTE OPTIMIZATION EXAMPLE

 1400

Node 11:
Preferred Gateway: GW2

Routing Scenarios:

To GW2:

Possible Routes: 11>GW2; 11>12>GW2; 11>13>GW2; 11>22>GW2; 11>13>22>GW2;

Routes via Initial Discovery: 11>12>GW2; 11>22>GW2; 11>13>GW2

Routes via Optimization 1: 11>12>GW2;

Route via Optimization 2: 11>GW2

To GW1:

Possible Routes: 11> (all 1>GW1 routes); 11>4>GW1; 11>7>GW1; 11>2>4>GW1; 11>2>5>GW1; 11>6>18>GW1;

Optimized Route: 11>7>GW1

To GW3:

Possible Routes: 11>14>GW3; 11>14>15>GW3; 11>15>GW3; 11>15>25>GW3; 11>10>25>GW3;
 11>10>9>16>GW3

Optimized Route: 1>15>GW3

15/22

FIG. 15
NODE 9
ROUTE OPTIMIZATION EXAMPLE

 1500

Node 9:
Preferred Gateway: GW3

Routing Scenarios:

To GW3:

Possible Routes: 9>16>GW3; 9>25>GW3; 9>16>25>GW3; 9>17>GW3; 9>17>26>GW3;

Routes via Initial Discovery: 9>16>GW3; 9>25>GW3; 9>16>25>GW3; 9>17>GW3; 9>17>26>GW3;

Routes via Optimization 1: 9>16>GW3; 9>25>GW3;

Route via Optimization 2: 9>16>GW3;

To GW2:

Possible Routes: 9>13>GW2; 9>10>GW2; 9>10>11>GW2; 9>10>13>GW2; 9>10>11>12>GW2;

Optimized Route: 9>13>GW2

To GW1:

Possible Routes: 9>6>GW1; 9> (all 1>GW1 routes); 9>8>18>GW1; 9>5>GW1; 9>8>6>GW1;

Optimized Route: 9>6>GW1

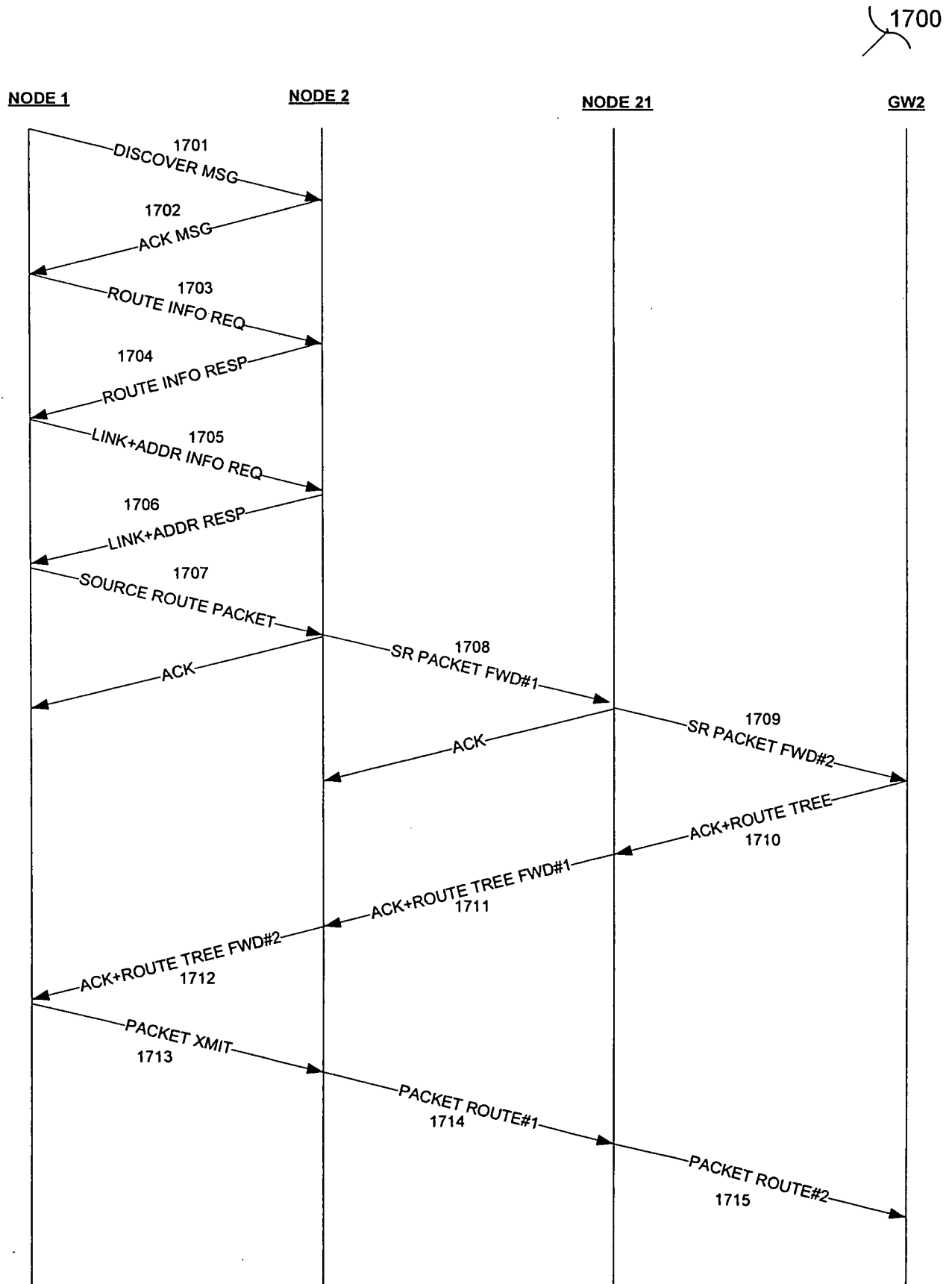
16/22

FIG. 16
RETURN ROUTES TO NODES FROM GATEWAYS
EXAMPLE

1600

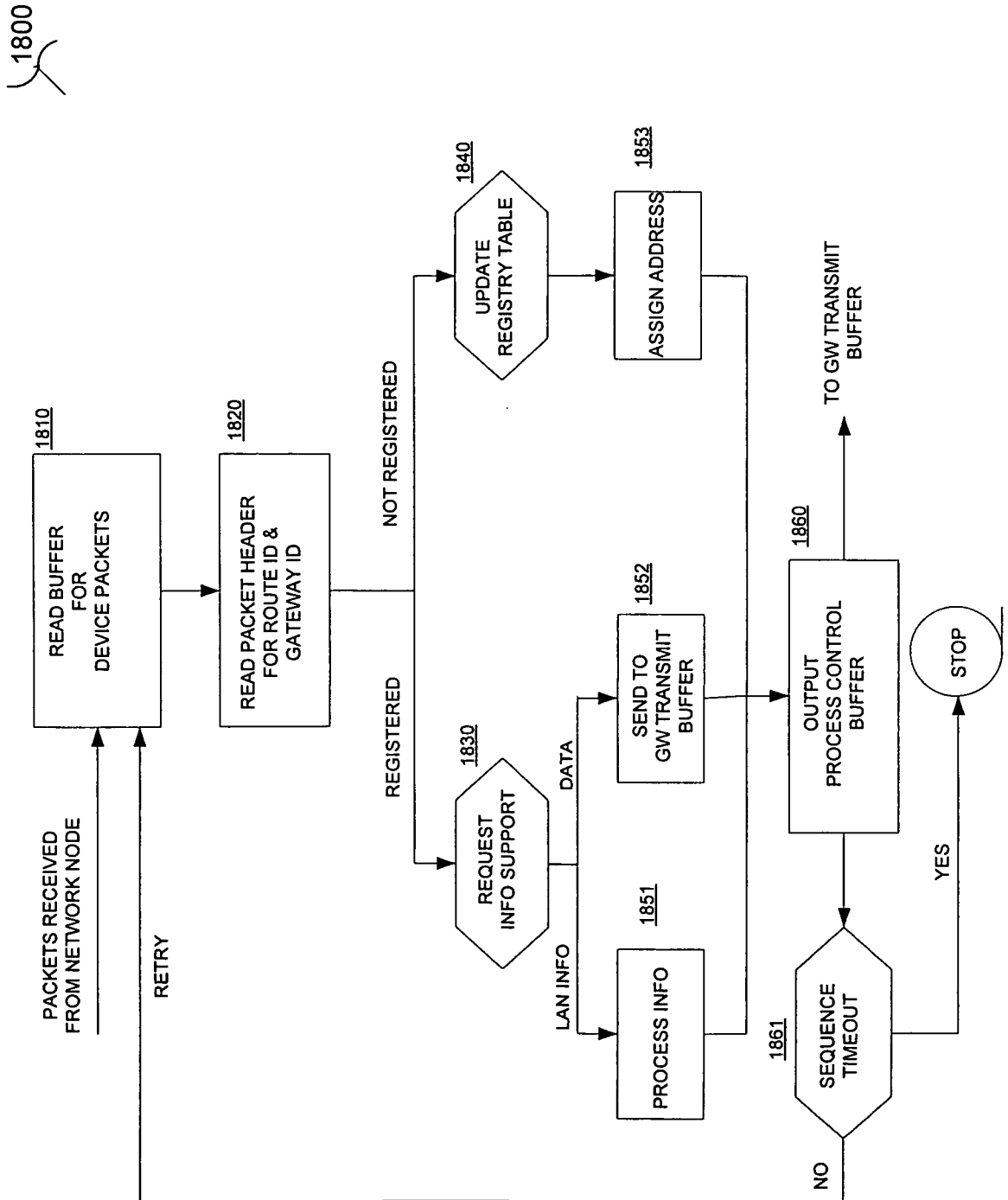
Gateway	Route	Node 1	Node 9	Node 11
GW1	Received Packet Route ←	1>5>GW1	9>8>6>GW1	11>7>GW1
	Return Packet Route →	GW1>5>1	GW1>6>8>9	GW1>7>11
GW2	Received Packet Route ←	1>2>21>GW2	9>10>13>GW2	11>12>GW2
	Return Packet Route →	GW2>21>2>1	GW2>13>10>9	GW2>12>11
GW3	Received Packet Route ←	1>9>16>GW3	9>16>GW3	11>10>25>GW3
	Return Packet Route →	GW3>16>9>1	GW3>16>9	GW3>25>10>11

17/22

FIG. 17
ROUTE SET-UP

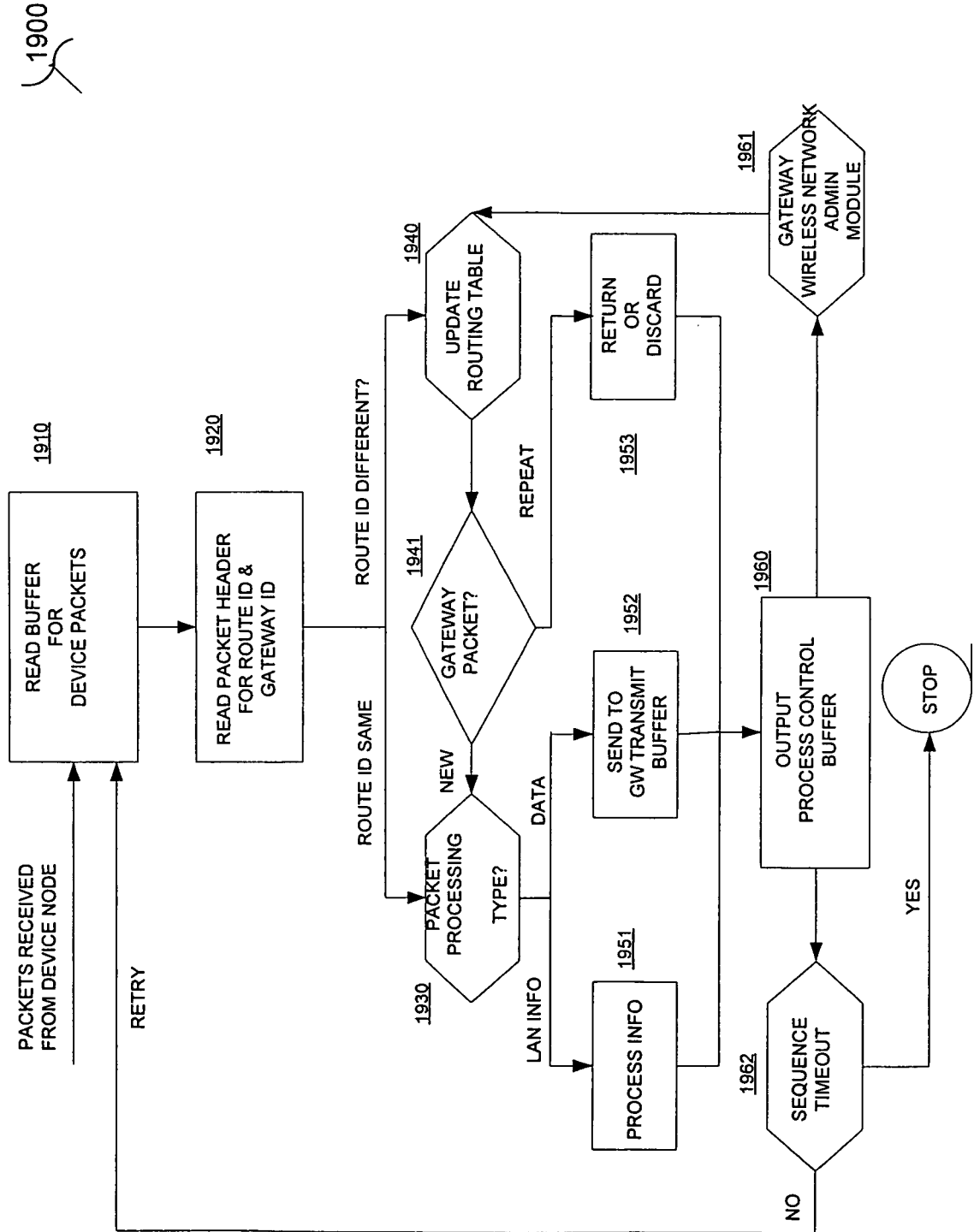
18/22

FIG. 18
GATEWAY PROCESS CONTROL REGISTRATION



19/22

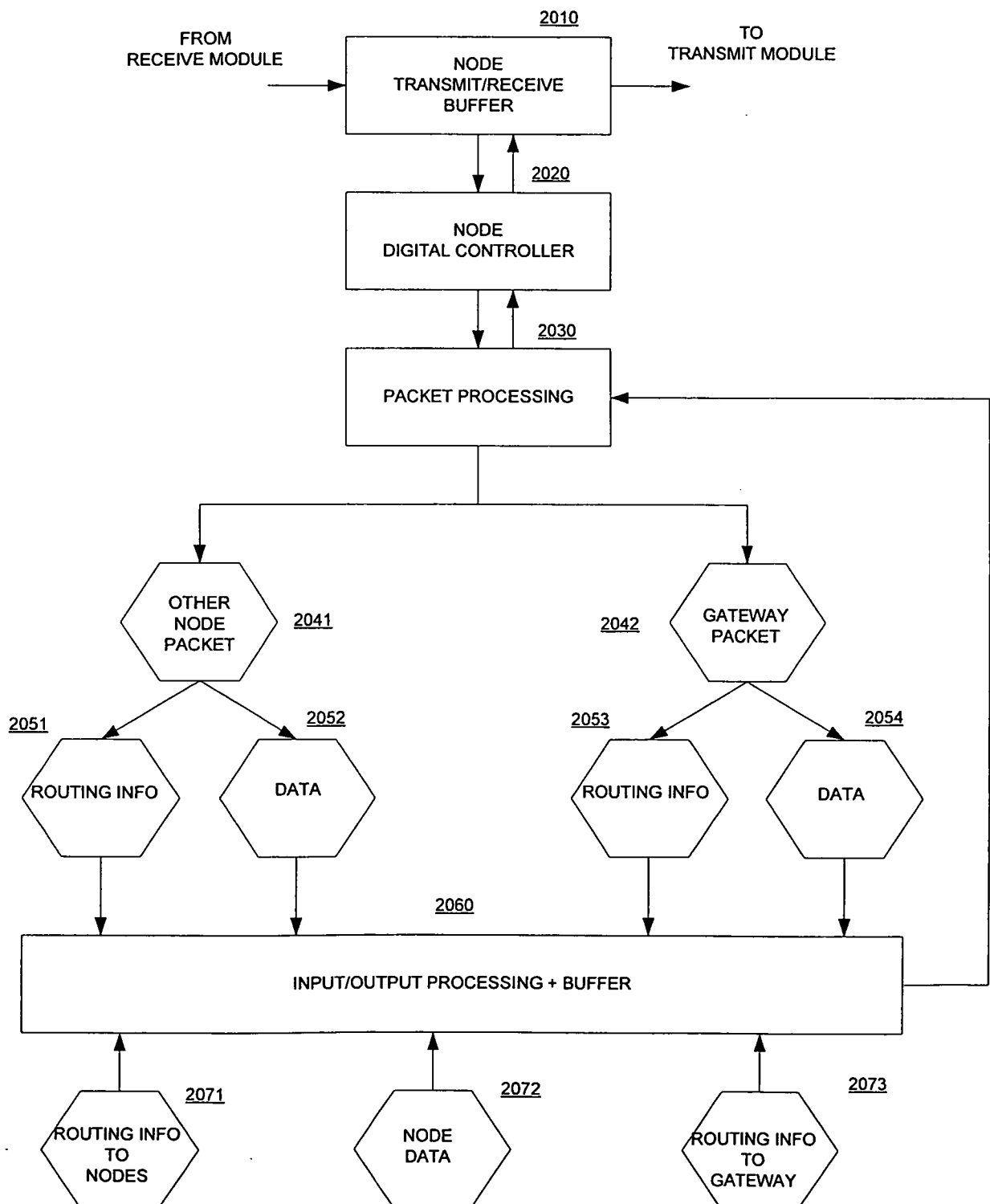
FIG. 19
GATEWAY PROCESS CONTROL-ROUTING



20/22

FIG. 20
NODE PROCESS
CONTROL

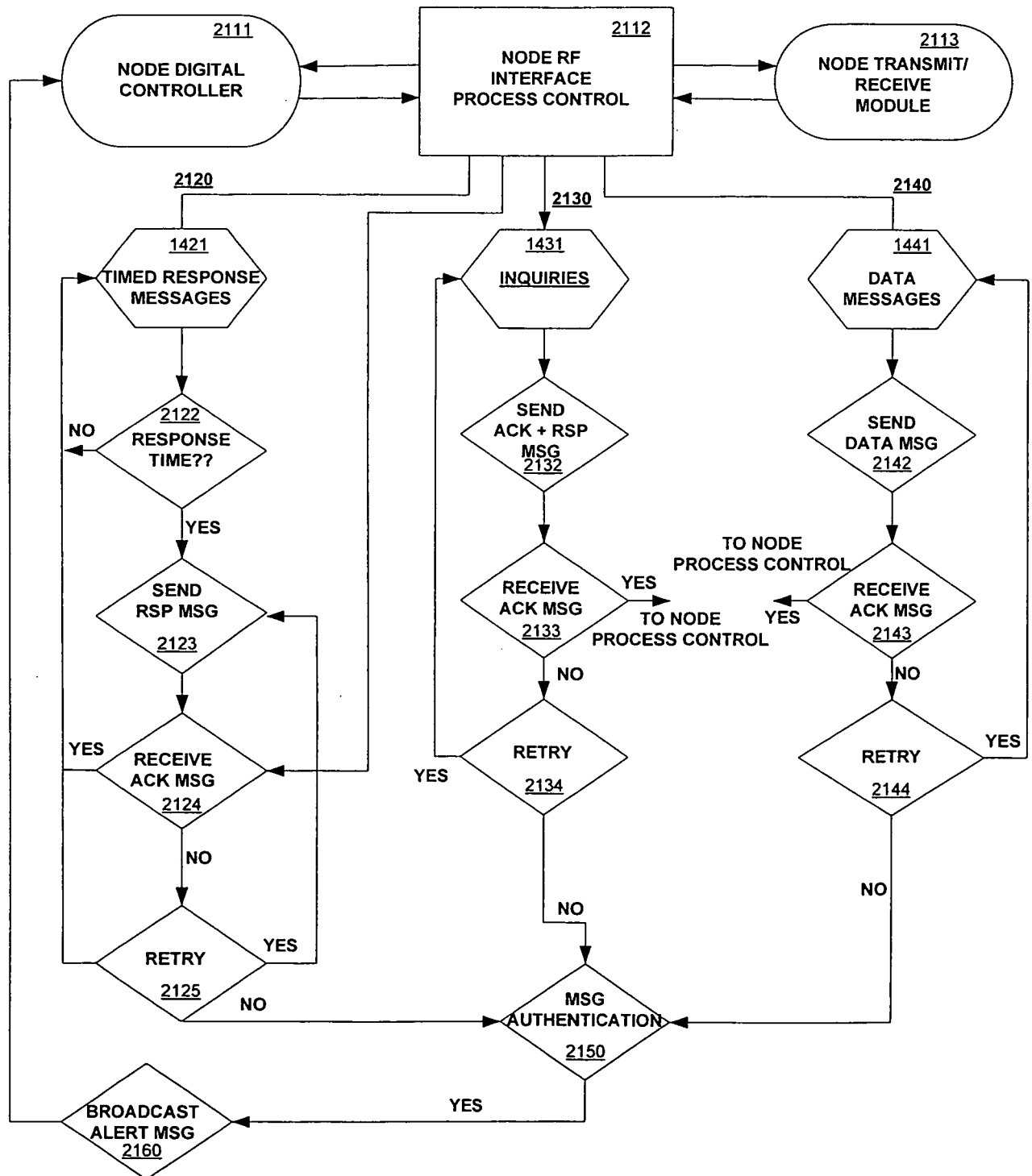
2000



21/22

FIG. 21
NODE RF INTERFACE
PROCESS CONTROL

2100



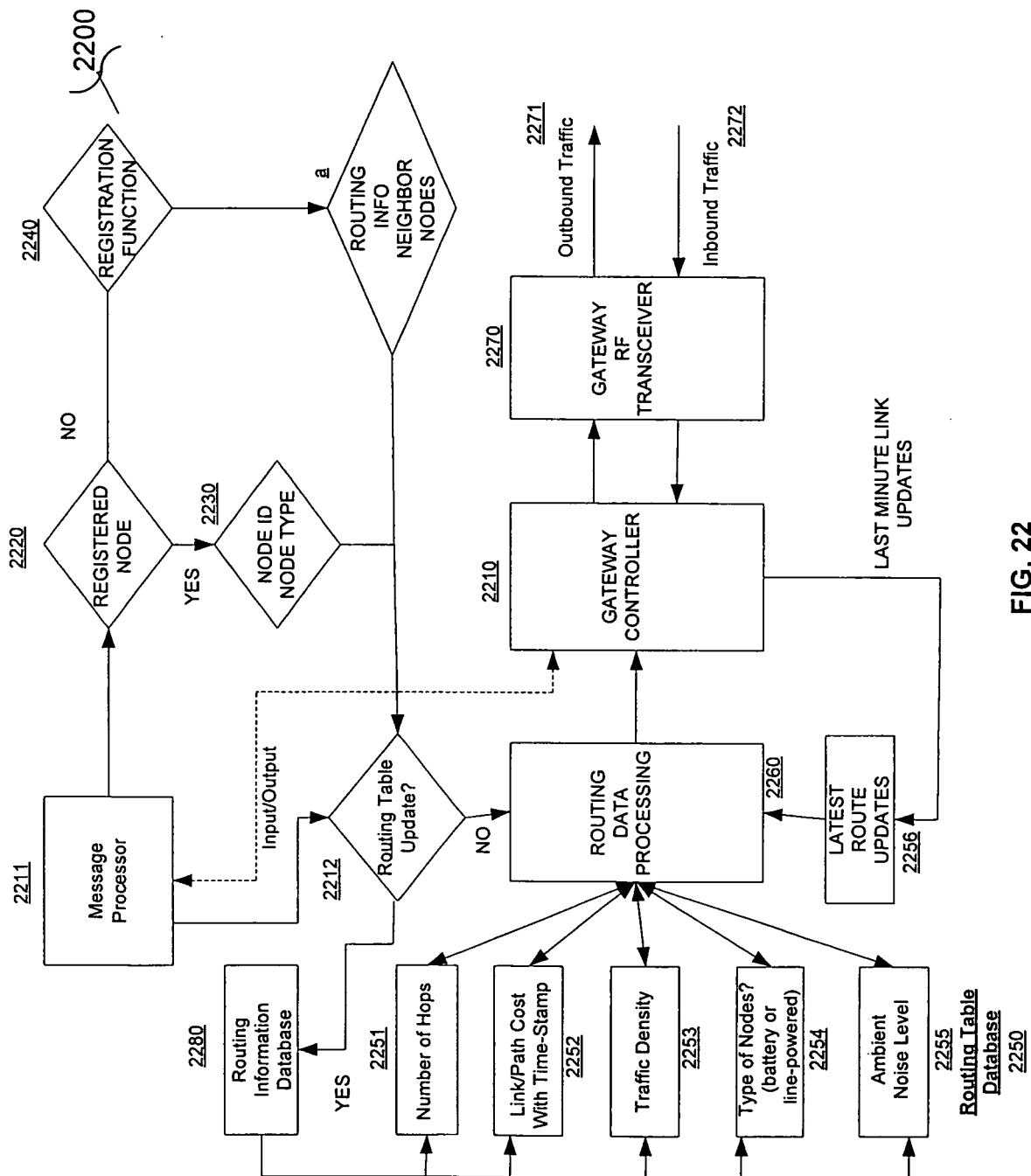


FIG. 22
GATEWAY ROUTING TABLE
UPDATE PROCESS