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Bullock et al.

(54) **SYSTEMS AND METHODS FOR DIAGNOSTIC, PERFORMANCE AND FAULT MANAGEMENT OF A NETWORK**

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(73) Assignee: **NEUTRAL TANDEM, INC. D/B/A INTELIQUENT**, Chicago, IL (US)

(21) Appl. No.: **13/783,163**

(22) Filed: **Mar. 1, 2013**

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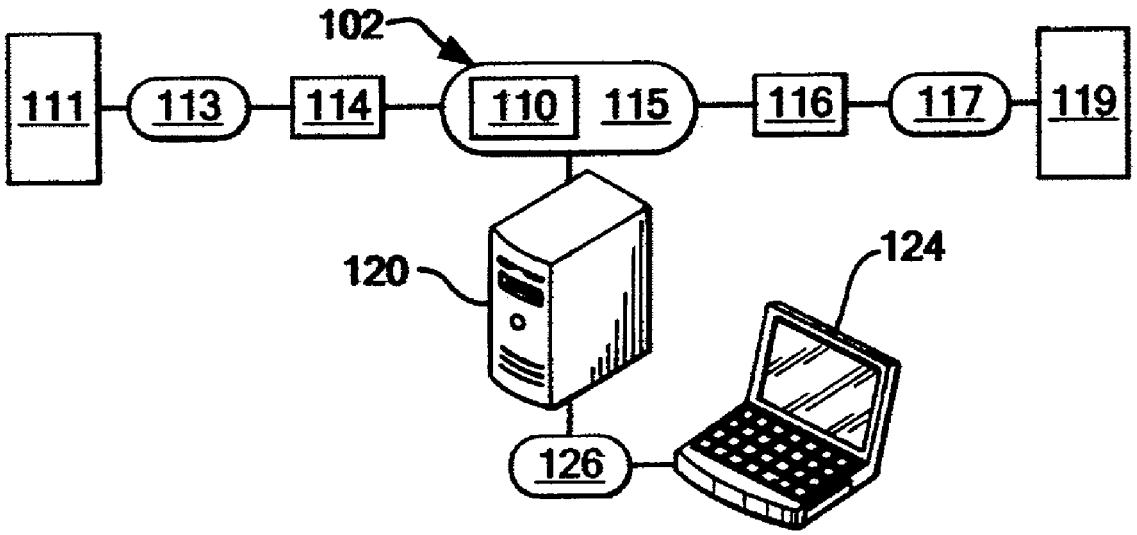
H04L 12/26 (2006.01)

(52) **U.S. Cl.**
CPC *H04L 43/045* (2013.01)
USPC **709/224**

(57) **ABSTRACT**

A system for analyzing, monitoring and detecting fault and performance across a network comprised of one or more networks of external elements, wherein the networks may be under different administrations. Among other things, the system permits users to monitor the connectivity status of the different links of the network; provides users event and system performance information; permits users to isolate certain portions of the network and review system performance data and events related to those isolated portions of the network; and permits such fault management across multiple connected networks, portions of which may be owned by different parties.



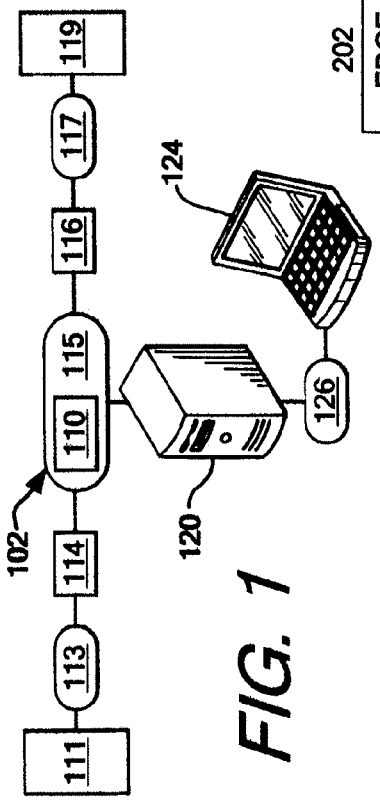

111
113
114
102
110
115
116
117
119
120
124
126

FIG. 1

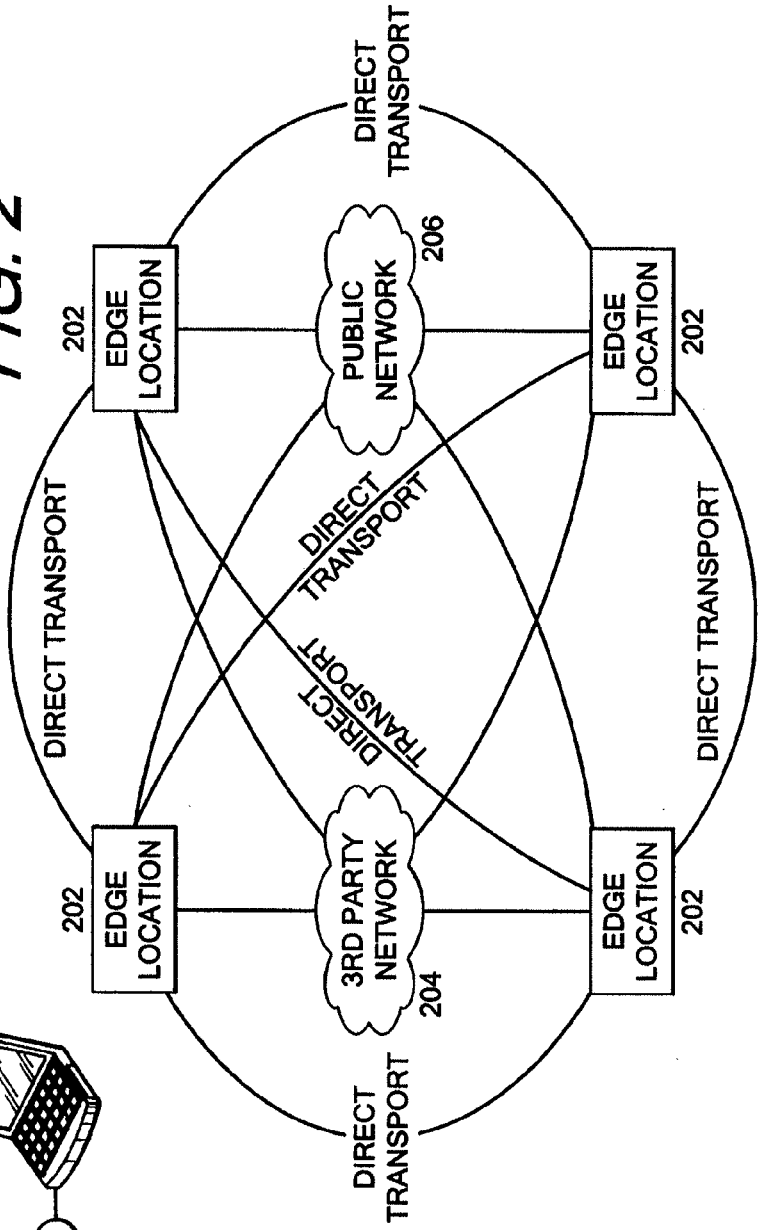

EDGE LOCATION
202
PUBLIC NETWORK
206
3RD PARTY NETWORK
204
DIRECT TRANSPORT
DIRECT TRANSPORT
DIRECT TRANSPORT
DIRECT TRANSPORT
DIRECT TRANSPORT
DIRECT TRANSPORT

FIG. 2

FIG. 4A

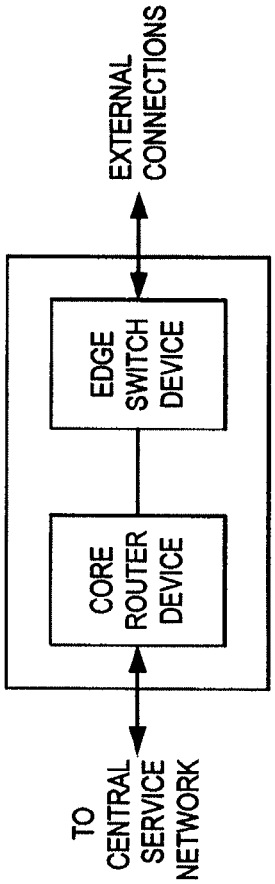


FIG. 4B

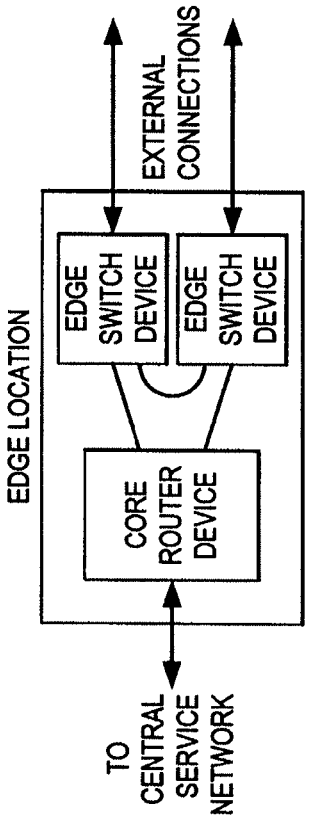


FIG. 3A

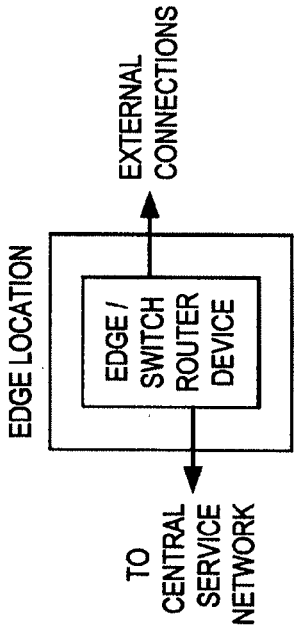


FIG. 3B

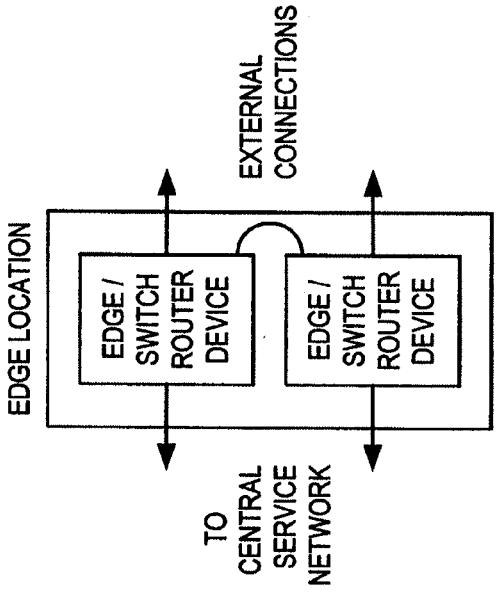


FIG. 5

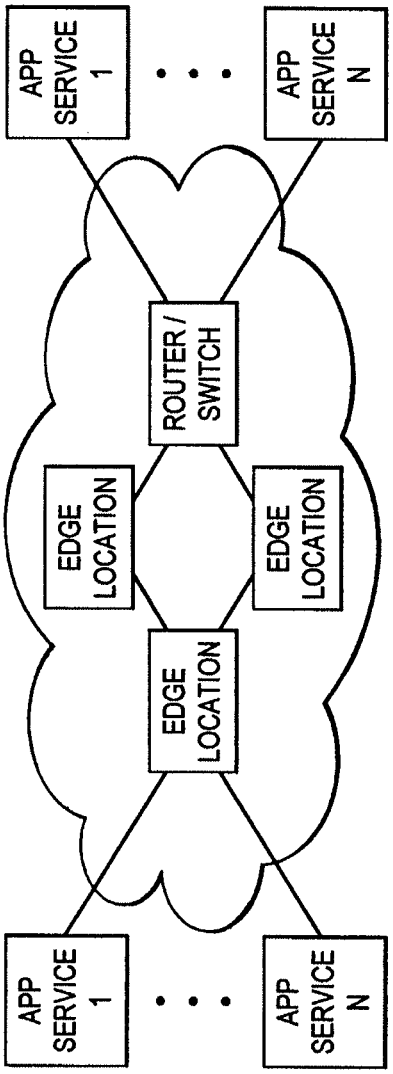

APP SERVICE 1
APP SERVICE N
ROUTER / SWITCH
EDGE LOCATION
EDGE LOCATION
EDGE LOCATION
APP SERVICE 1
APP SERVICE N

FIG. 6

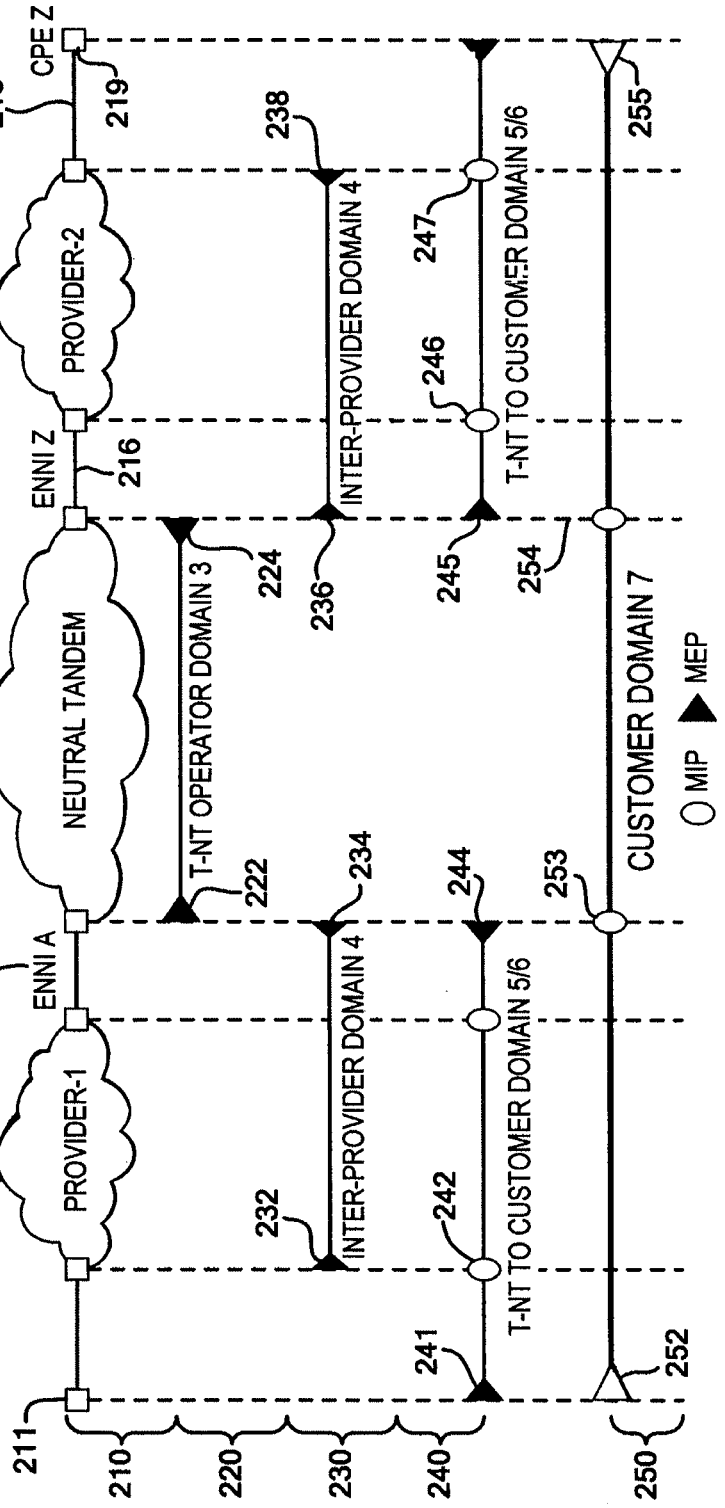
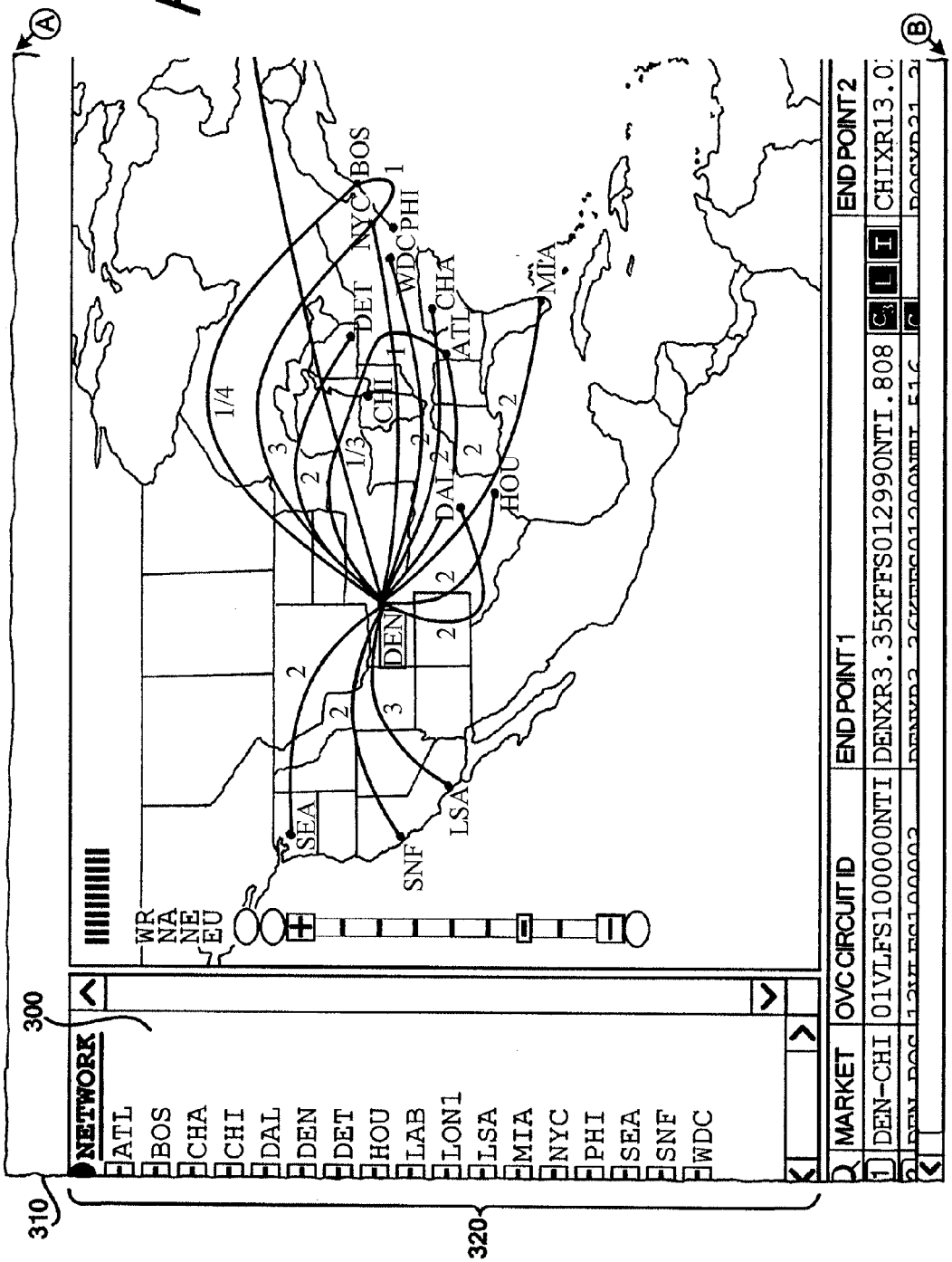

CPE Z
218
219
255
238
247
217
PROVIDER-2
INTER-PROVIDER DOMAIN 4
T-NT TO CUSTOMER DOMAIN 5/6
246
ENNI Z
216
215
NEUTRAL TANDEM
T-NT OPERATOR DOMAIN 3
224
236
245
254
214
ENNI A
222
234
244
253
CUSTOMER DOMAIN 7
213
PROVIDER-1
INTER-PROVIDER DOMAIN 4
T-NT TO CUSTOMER DOMAIN 5/6
232
242
241
252
211
210
220
230
240
250
MIP
MEP

FIG. 7


A
B
300
310
320
NETWORK
ATL
BOS
CHA
CHI
DAL
DEN
DET
HOU
LAB
LON1
LSA
MIA
NYC
PHI
SEA
SNF
WDC
WR
NA
NE
EU
SEA
SNF
LSA
DEN
DAL
HOU
CHI
DET
NYC
BOS
PHI
WDC
ATL
CHA
MIA
1/4
1/3
MARKET
OVC CIRCUIT ID
END POINT 1
END POINT 2
DEN-CHI
01VLFS100000NTI
DENXR3.35KFFS012990NTI.808
CHIXR13.0

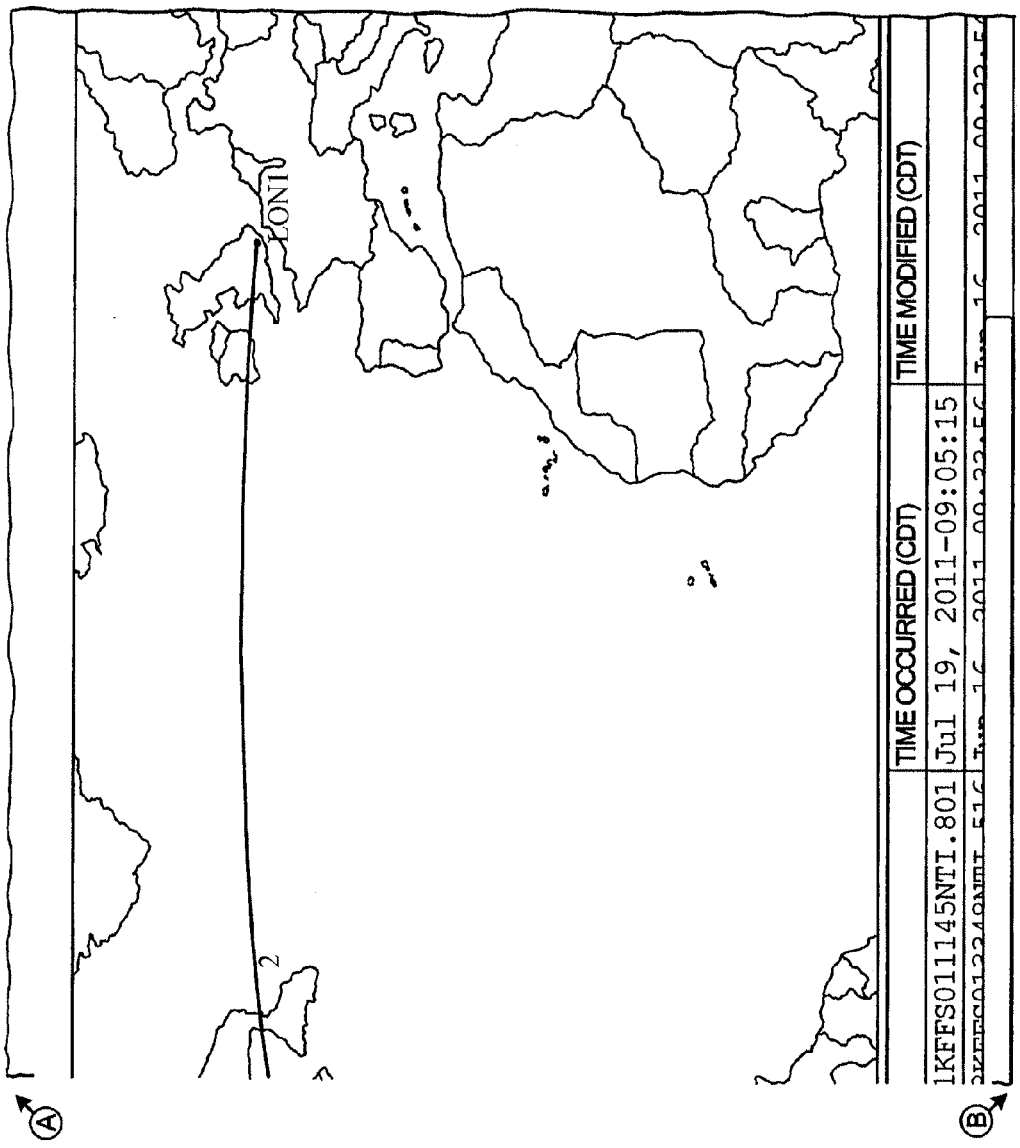

LONI
2
A
B
TIME OCCURRED (CDT)
TIME MODIFIED (CDT)
IKFES011145NTI.801
Jul 19, 2011-09:05:15

FIG. 7

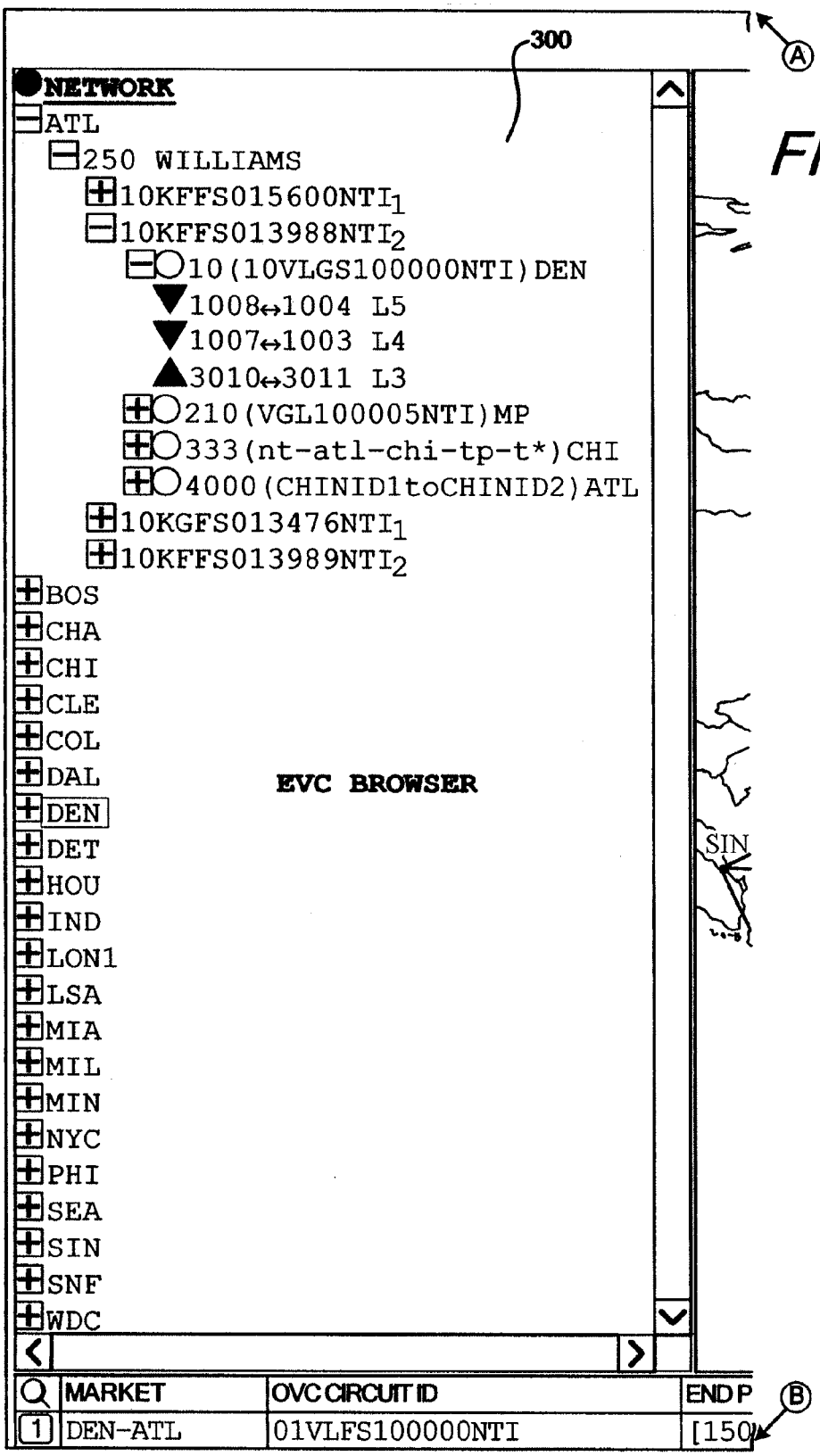

300
A
NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI2
10(10VLGS100000NTI)DEN
1008↔1004 L5
1007↔1003 L4
3010↔3011 L3
210(VGL100005NTI)MP
333(nt-atl-chi-tp-t*)CHI
4000(CHINID1toCHINID2)ATL
10KGFS013476NTI1
10KFFS013989NTI2
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
MIN
NYC
PHI
SEA
SIN
SNF
WDC
EVC BROWSER
SIN
MARKET
OVC CIRCUIT ID
END P
1
DEN-ATL
01VLFS100000NTI
[150
B

FIG. 8

FIG. 8

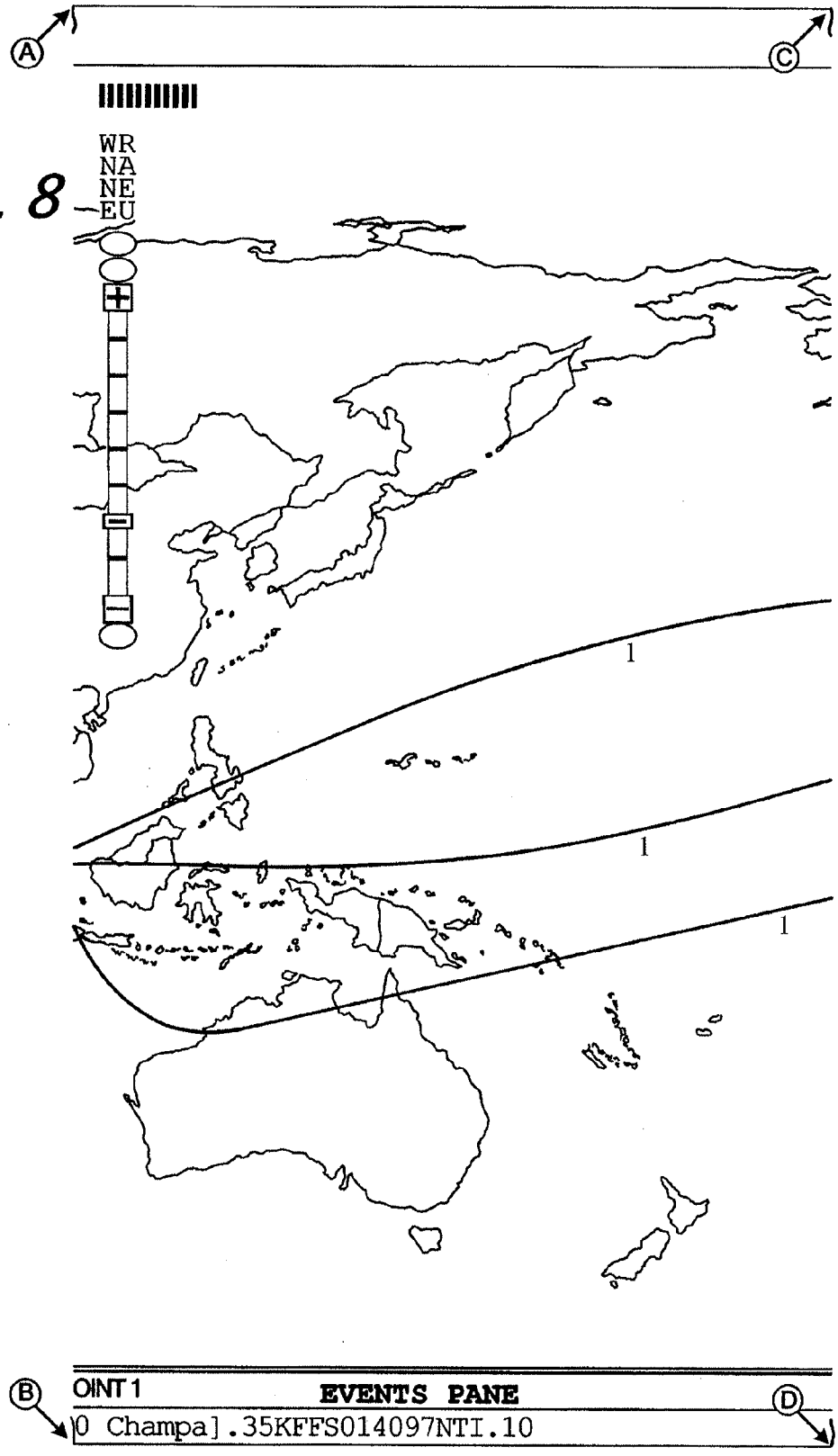
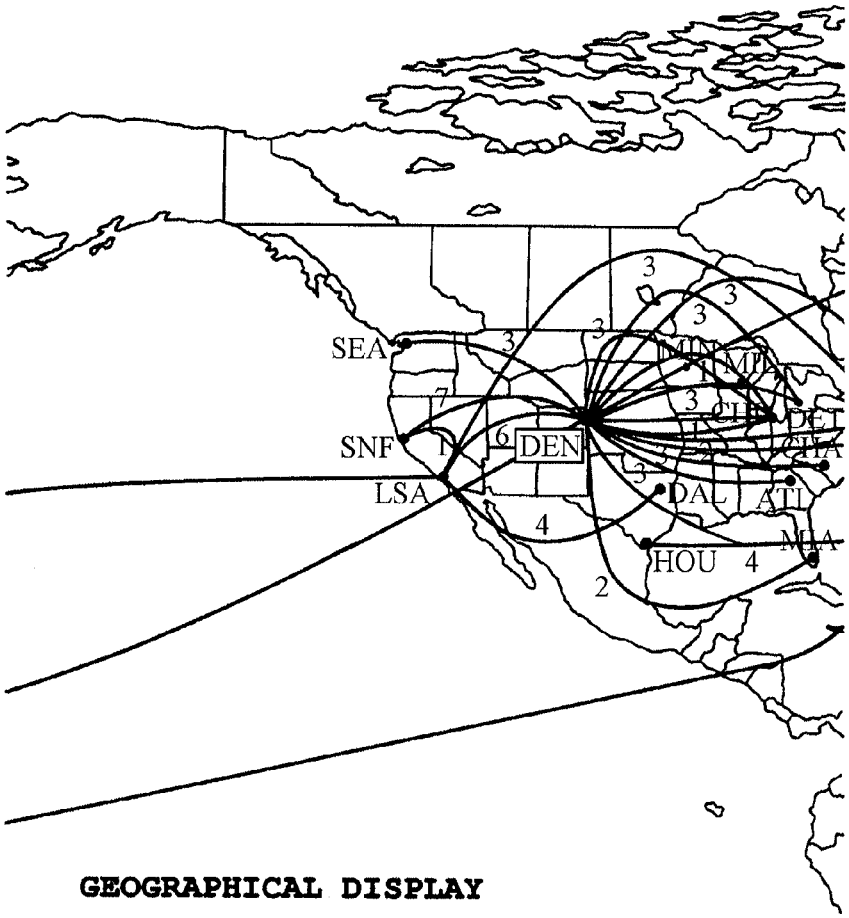

A
C
WR
NA
NE
EU
1
1
1
B
OINT 1
EVENTS PANE
D
0 Champa].35KFFS014097NTI.10

FIG. 8



GEOGRAPHICAL DISPLAY

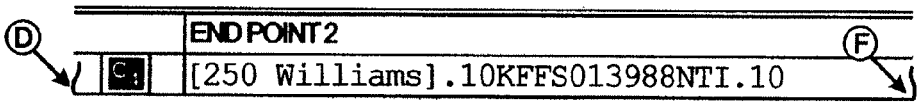


FIG. 8

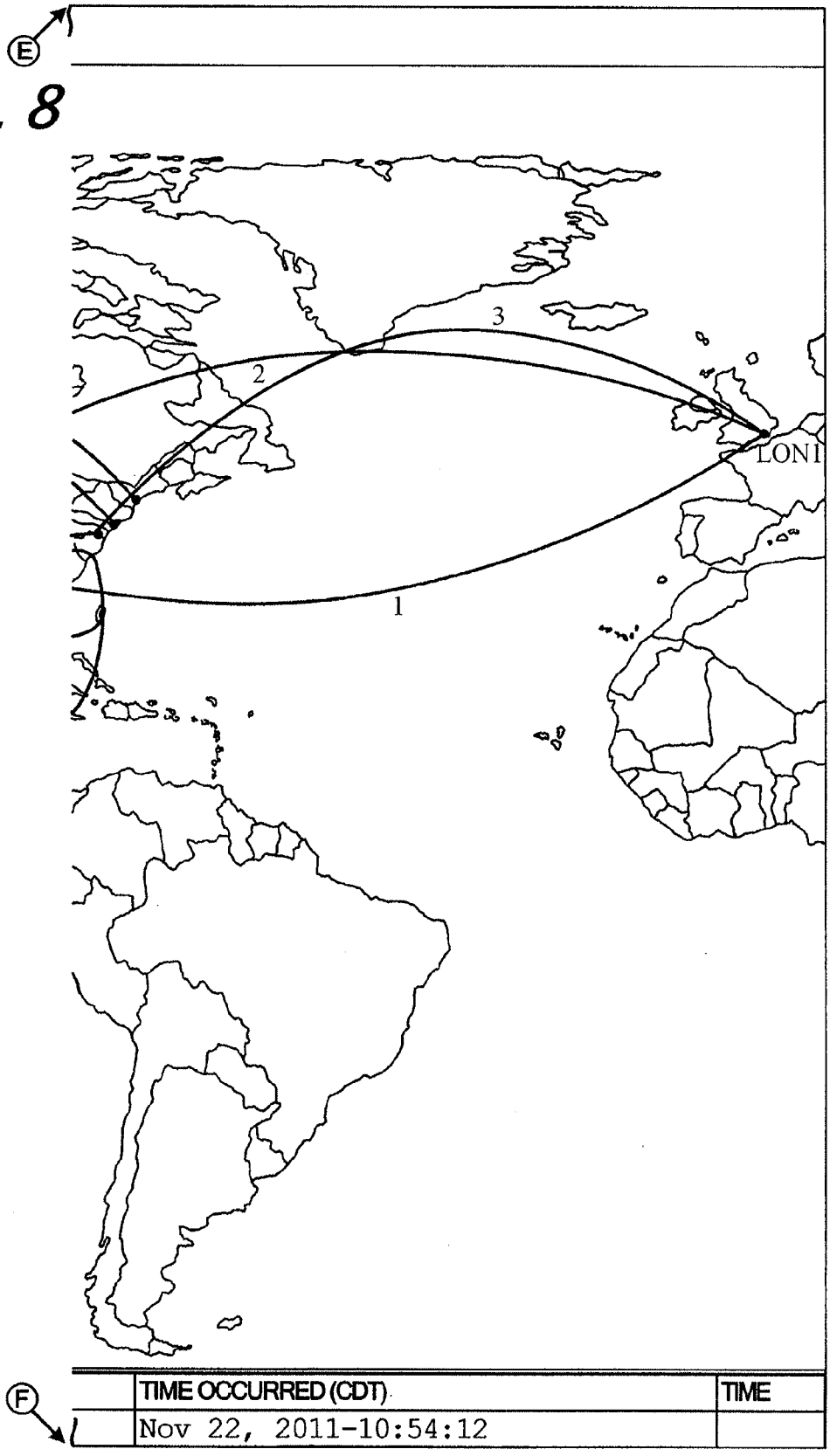


FIG. 9

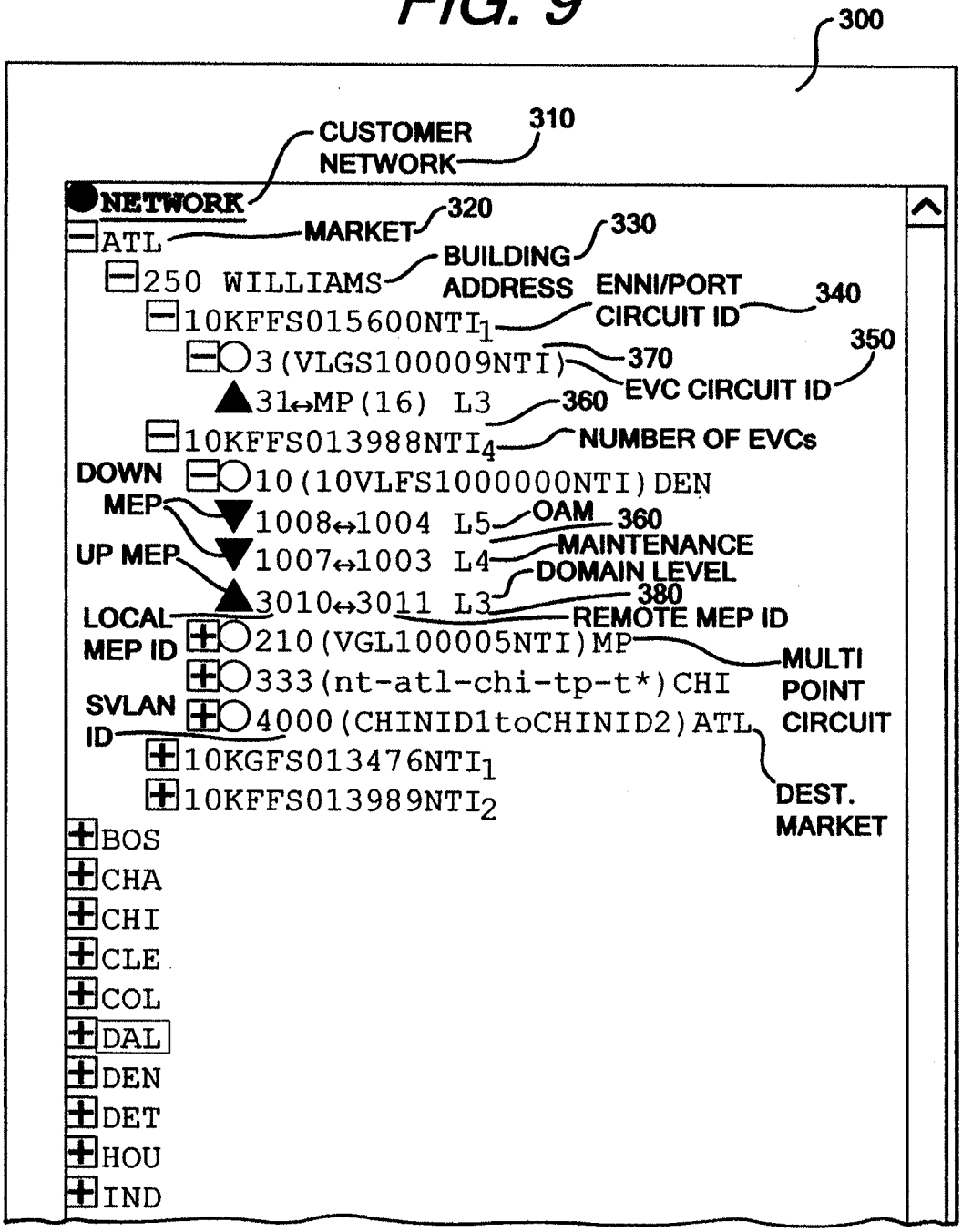

300
CUSTOMER NETWORK
310
NETWORK
320
MARKET
330
BUILDING ADDRESS
ENNI/PORT CIRCUIT ID
340
350
370
EVC CIRCUIT ID
360
NUMBER OF EVCs
DOWN MEP
UP MEP
OAM MAINTENANCE DOMAIN LEVEL
380
REMOTE MEP ID
LOCAL MEP ID
MULTI POINT CIRCUIT
SVLAN ID
DEST. MARKET
ATL
250 WILLIAMS
10KFFS015600NTI1
3(VLGS100009NTI)
31↔MP(16) L3
10KFFS013988NTI4
10(10VLFS1000000NTI)DEN
1008↔1004 L5
1007↔1003 L4
3010↔3011 L3
210(VGL100005NTI)MP
333(nt-atl-chi-tp-t*)CHI
4000(CHINID1toCHINID2)ATL
10KGFS013476NTI1
10KFFS013989NTI2
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND

FIG. 10

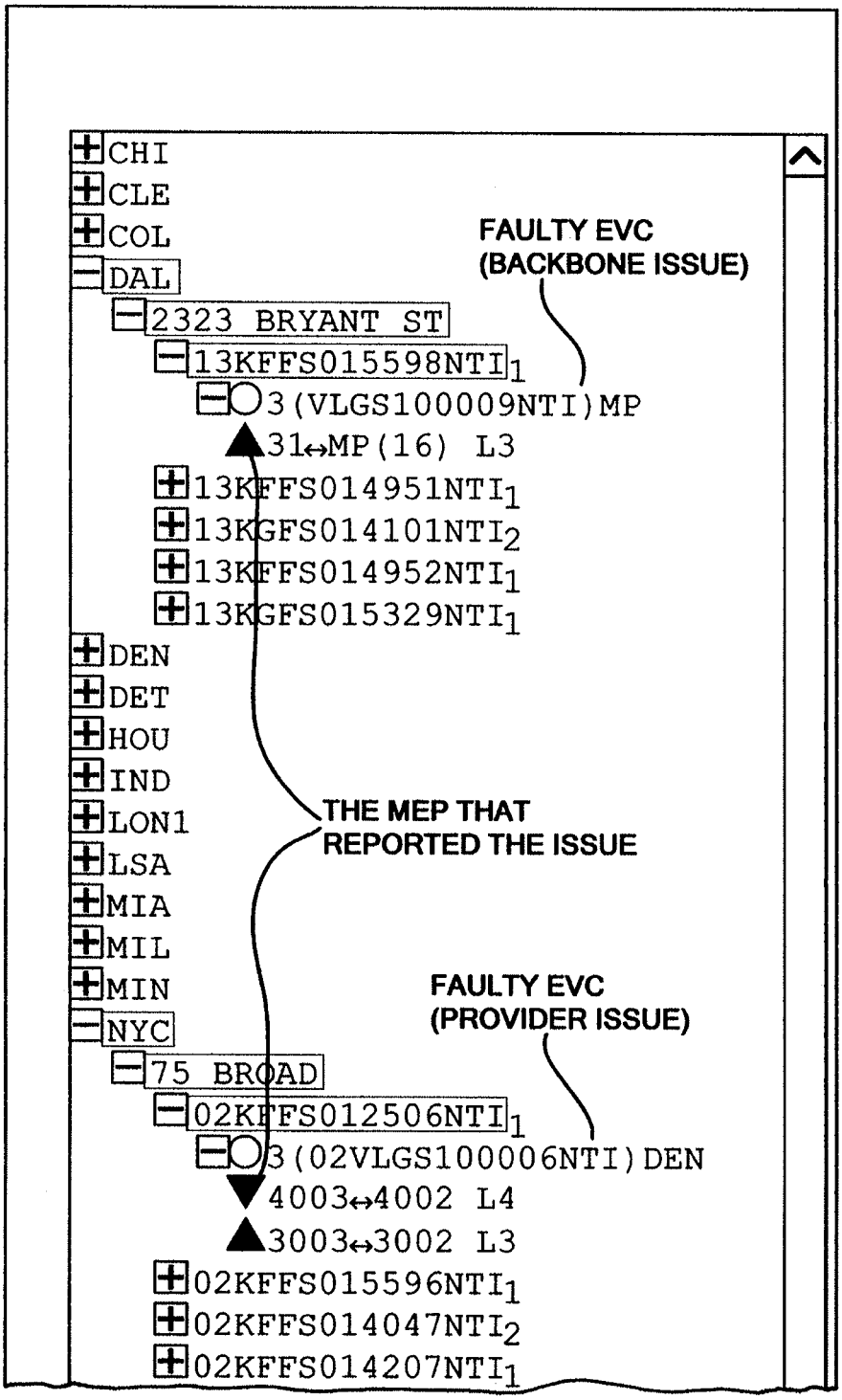

CHI
CLE
COL
DAL
2323 BRYANT ST
13KFFS015598NTI1
3(VLGS100009NTI)MP
31↔MP(16) L3
13KFFS014951NTI1
13KGFS014101NTI2
13KFFS014952NTI1
13KGFS015329NTI1
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
MIN
NYC
75 BROAD
02KFFS012506NTI1
3(02VLGS100006NTI)DEN
4003↔4002 L4
3003↔3002 L3
02KFFS015596NTI1
02KFFS014047NTI2
02KFFS014207NTI1
FAULTY EVC
(BACKBONE ISSUE)
THE MEP THAT
REPORTED THE ISSUE
FAULTY EVC
(PROVIDER ISSUE)

FIG. 11

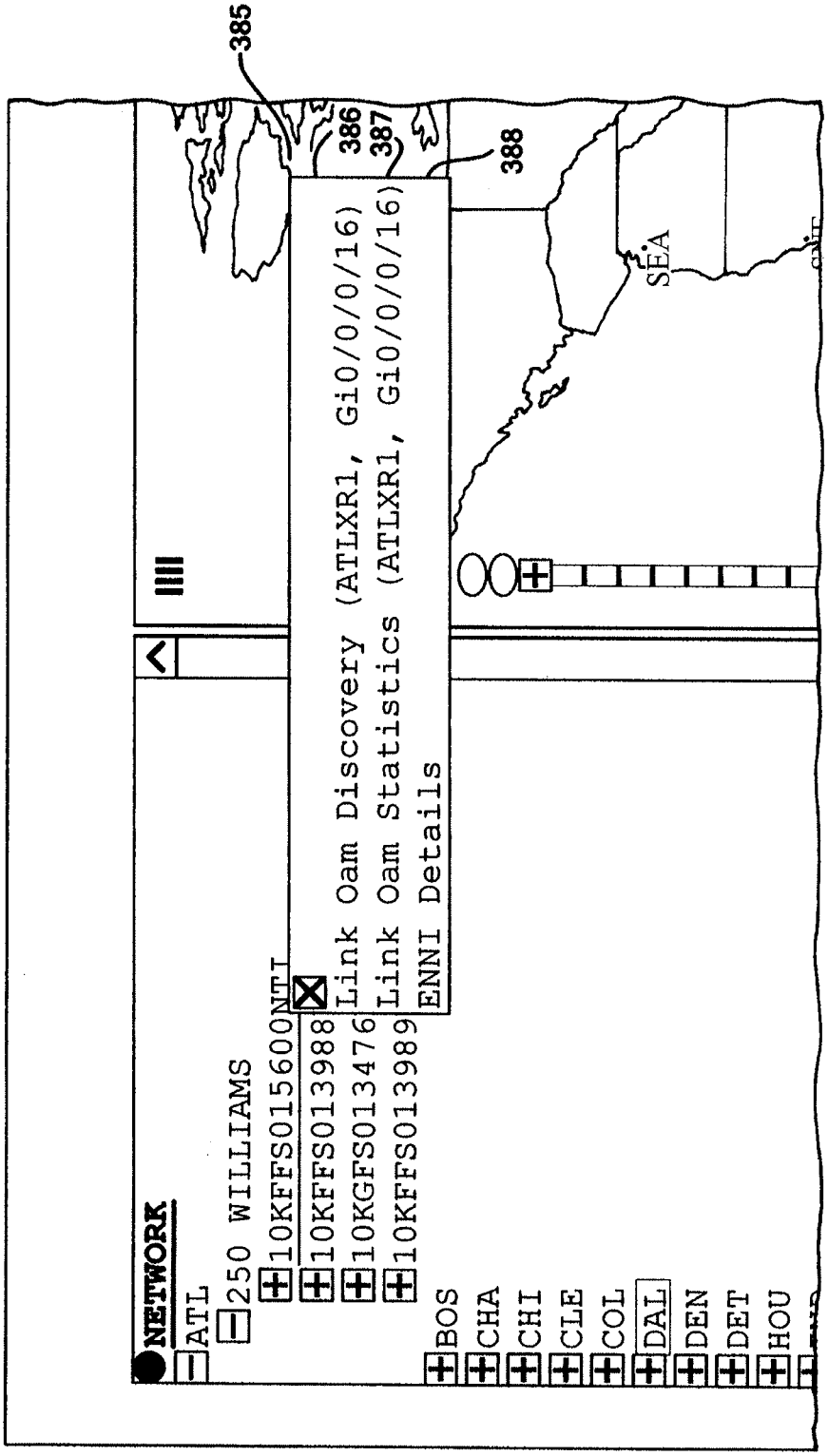

385
386
387
388
SEA
Link Oam Discovery (ATLXR1, Gi0/0/0/16)
Link Oam Statistics (ATLXR1, Gi0/0/0/16)
ENNI Details
NETWORK
ATL
250 WILLIAMS
10KFFS015600NTT
10KFFS013988
10KGFS013476
10KFFS013989
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU

FIG. 12

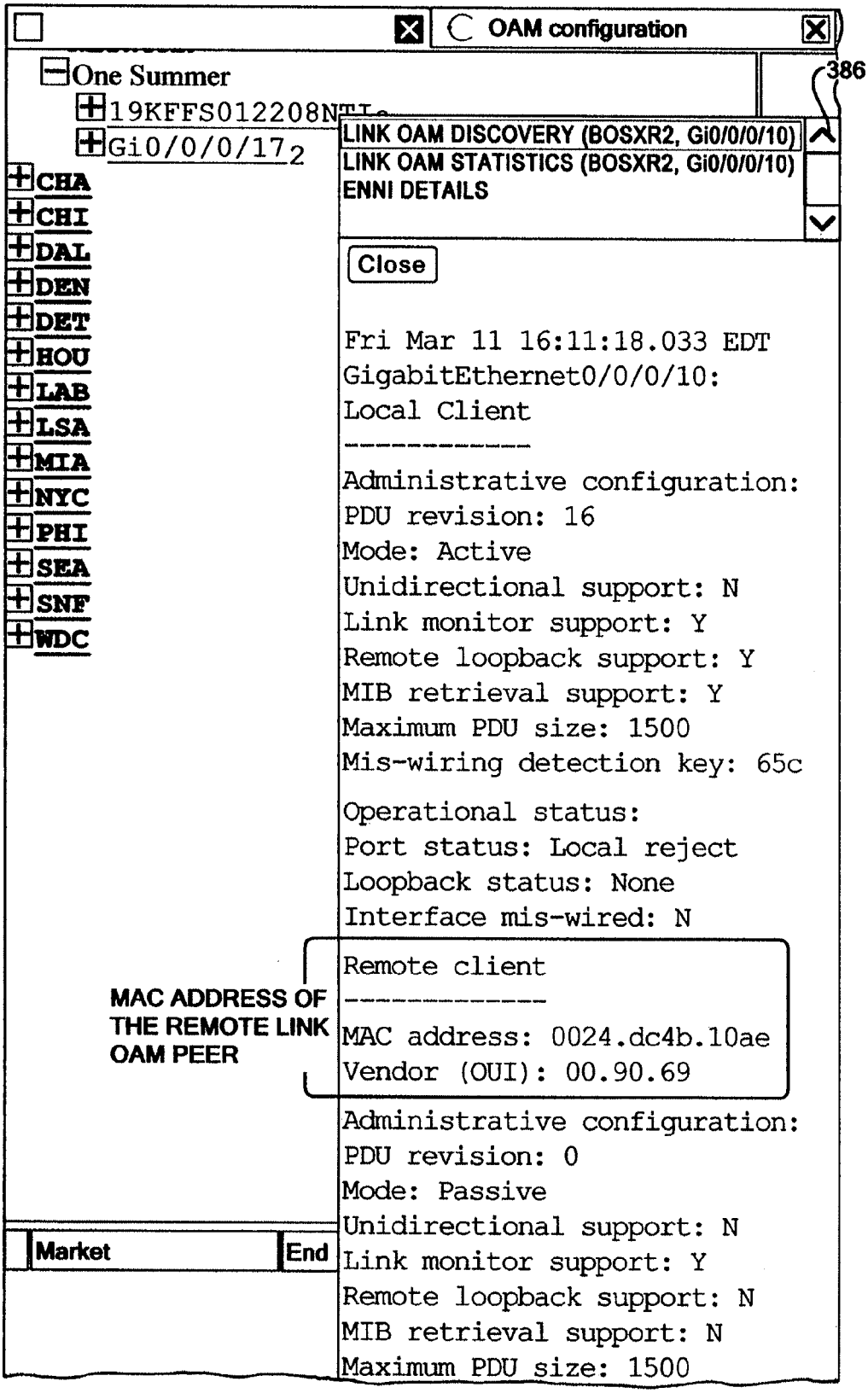
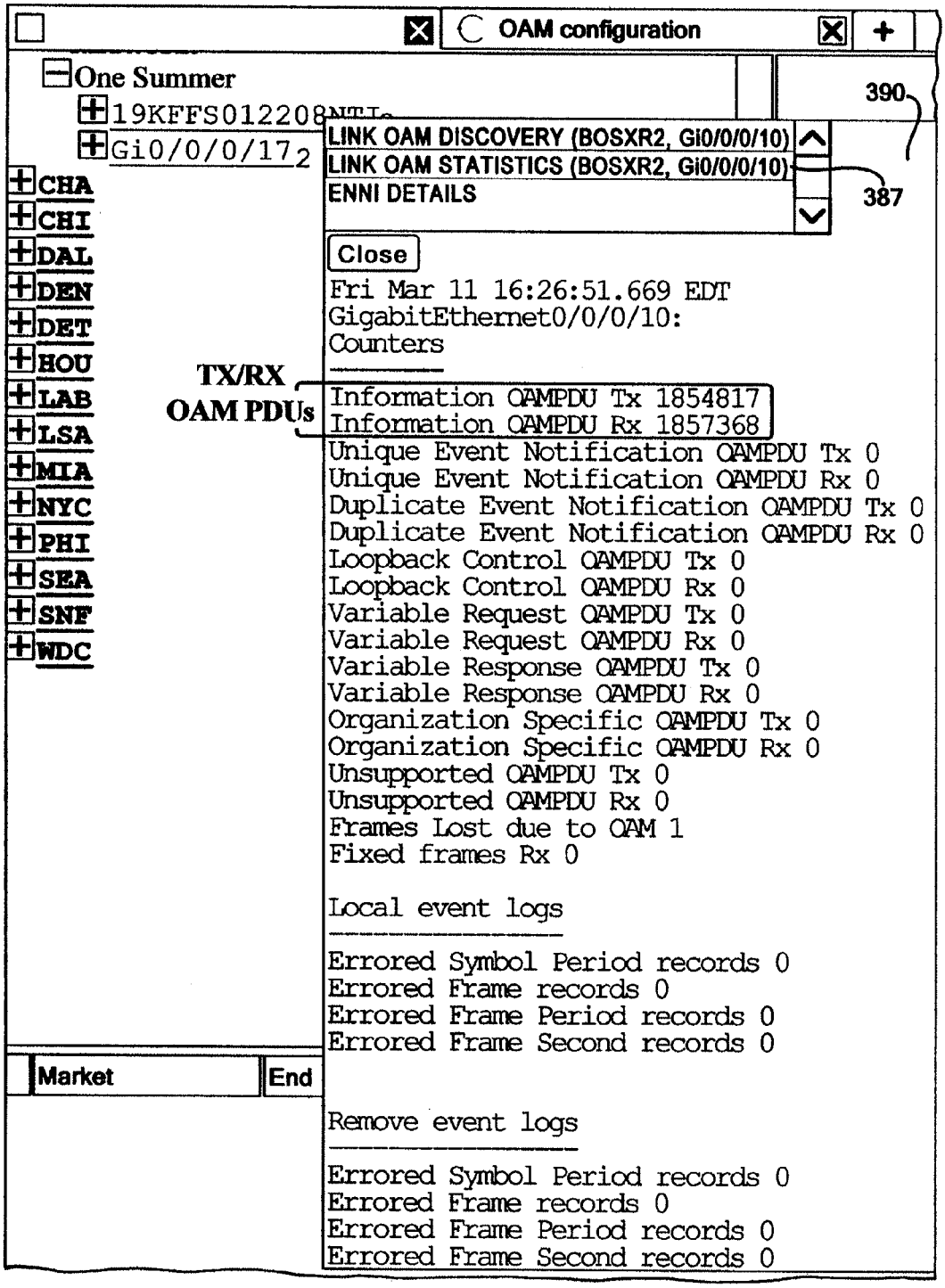

OAM configuration
One Summer
19KFFS012208NTL
Gi0/0/0/17_2
CHA
CHI
DAL
DEN
DET
HOU
LAB
LSA
MIA
NYC
PHI
SEA
SNF
WDC
Market
End
386
LINK OAM DISCOVERY (BOSXR2, Gi0/0/0/10)
LINK OAM STATISTICS (BOSXR2, Gi0/0/0/10)
ENNI DETAILS
Close
Fri Mar 11 16:11:18.033 EDT
GigabitEthernet0/0/0/10:
Local Client
Administrative configuration:
PDU revision: 16
Mode: Active
Unidirectional support: N
Link monitor support: Y
Remote loopback support: Y
MIB retrieval support: Y
Maximum PDU size: 1500
Mis-wiring detection key: 65c
Operational status:
Port status: Local reject
Loopback status: None
Interface mis-wired: N
Remote client
MAC address: 0024.dc4b.10ae
Vendor (OUI): 00.90.69
MAC ADDRESS OF THE REMOTE LINK OAM PEER
Administrative configuration:
PDU revision: 0
Mode: Passive
Unidirectional support: N
Link monitor support: Y
Remote loopback support: N
MIB retrieval support: N
Maximum PDU size: 1500

FIG. 13


OAM configuration
One Summer
19KFFS012208
Gi0/0/0/17
CHA
CHI
DAL
DEN
DET
HOU
LAB
LSA
MIA
NYC
PHI
SEA
SNF
WDC
Market
End
390
LINK OAM DISCOVERY (BOSXR2, Gi0/0/0/10)
LINK OAM STATISTICS (BOSXR2, Gi0/0/0/10)
ENNI DETAILS
387
Close
Fri Mar 11 16:26:51.669 EDT
GigabitEthernet0/0/0/10:
Counters
TX/RX
OAM PDUs
Information OAMPDU Tx 1854817
Information OAMPDU Rx 1857368
Unique Event Notification OAMPDU Tx 0
Unique Event Notification OAMPDU Rx 0
Duplicate Event Notification OAMPDU Tx 0
Duplicate Event Notification OAMPDU Rx 0
Loopback Control OAMPDU Tx 0
Loopback Control OAMPDU Rx 0
Variable Request OAMPDU Tx 0
Variable Request OAMPDU Rx 0
Variable Response OAMPDU Tx 0
Variable Response OAMPDU Rx 0
Organization Specific OAMPDU Tx 0
Organization Specific OAMPDU Rx 0
Unsupported OAMPDU Tx 0
Unsupported OAMPDU Rx 0
Frames Lost due to OAM 1
Fixed frames Rx 0
Local event logs
Errored Symbol Period records 0
Errored Frame records 0
Errored Frame Period records 0
Errored Frame Second records 0
Remove event logs
Errored Symbol Period records 0
Errored Frame records 0
Errored Frame Period records 0
Errored Frame Second records 0

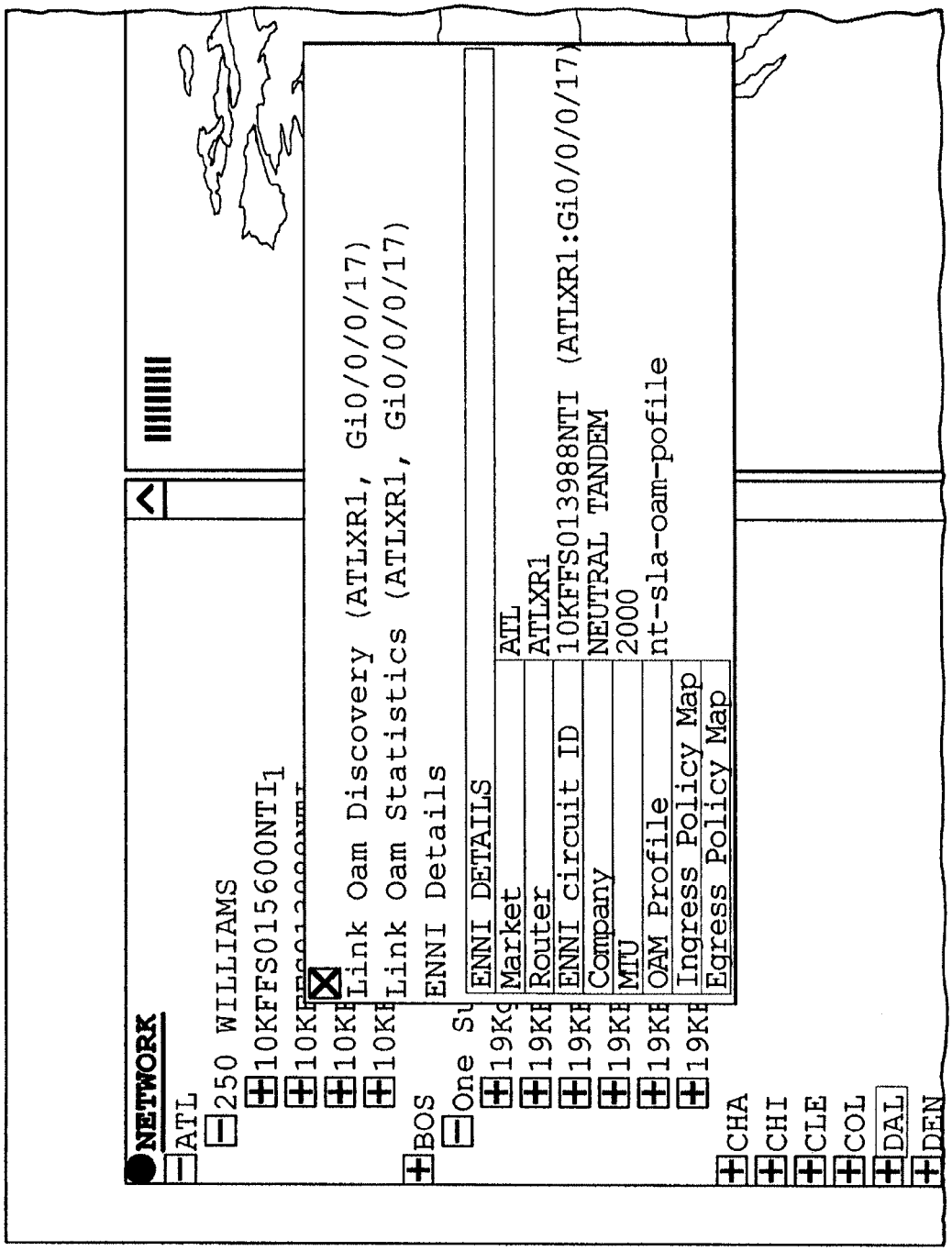

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
Link Oam Discovery (ATLXR1, Gi0/0/0/17)
Link Oam Statistics (ATLXR1, Gi0/0/0/17)
ENNI Details
ENNI DETAILS
Market
Router
ENNI circuit ID
Company
MTU
OAM Profile
Ingress Policy Map
Egress Policy Map
ATL
ATLXR1
10KFFS013988NTI (ATLXR1:Gi0/0/0/17)
NEUTRAL TANDEM
2000
nt-sla-oam-pofile
BOS
CHA
CHI
CLE
COL
DAL
DEN

FIG. 14

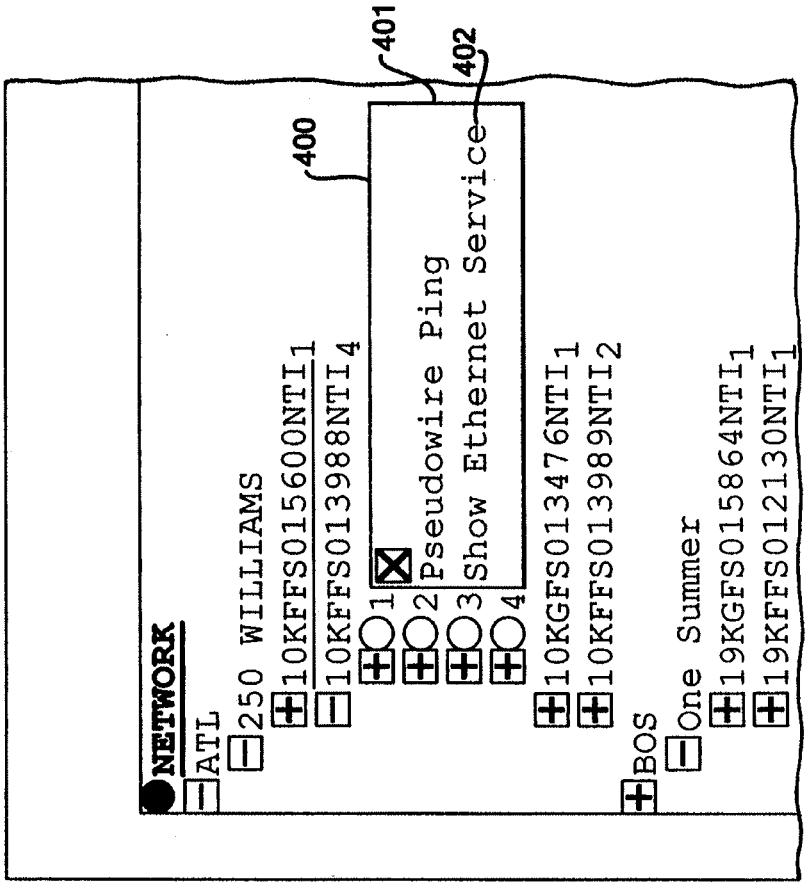
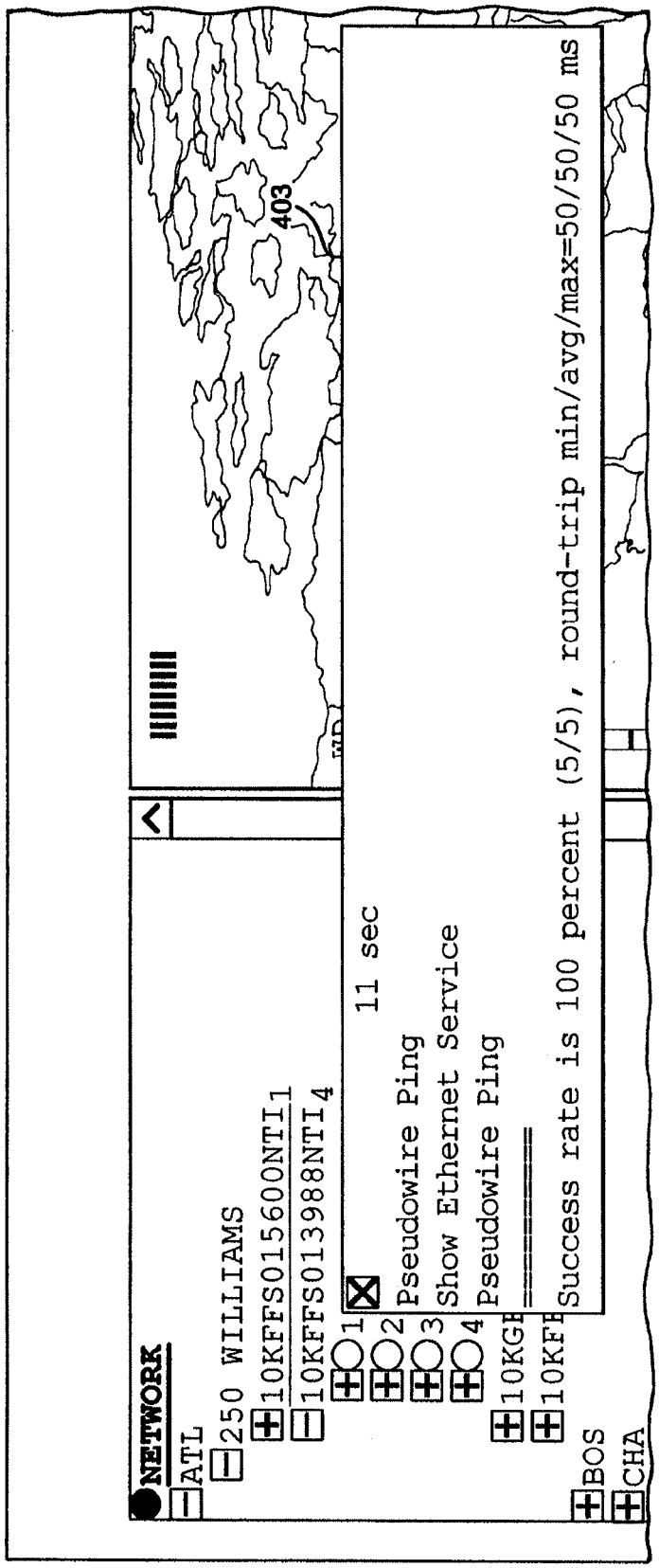

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
1
2
3
4
Pseudowire Ping
Show Ethernet Service
10KGFS013476NTI1
10KFFS013989NTI2
BOS
One Summer
19KGFS015864NTI1
19KFFS012130NTI1
400
401
402

FIG. 15

FIG. 16


NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
1
2
3
4
10KGF
10KFF
BOS
CHA
11 sec
Pseudowire Ping
Show Ethernet Service
Pseudowire Ping
Success rate is 100 percent (5/5), round-trip min/avg/max=50/50/50 ms
403

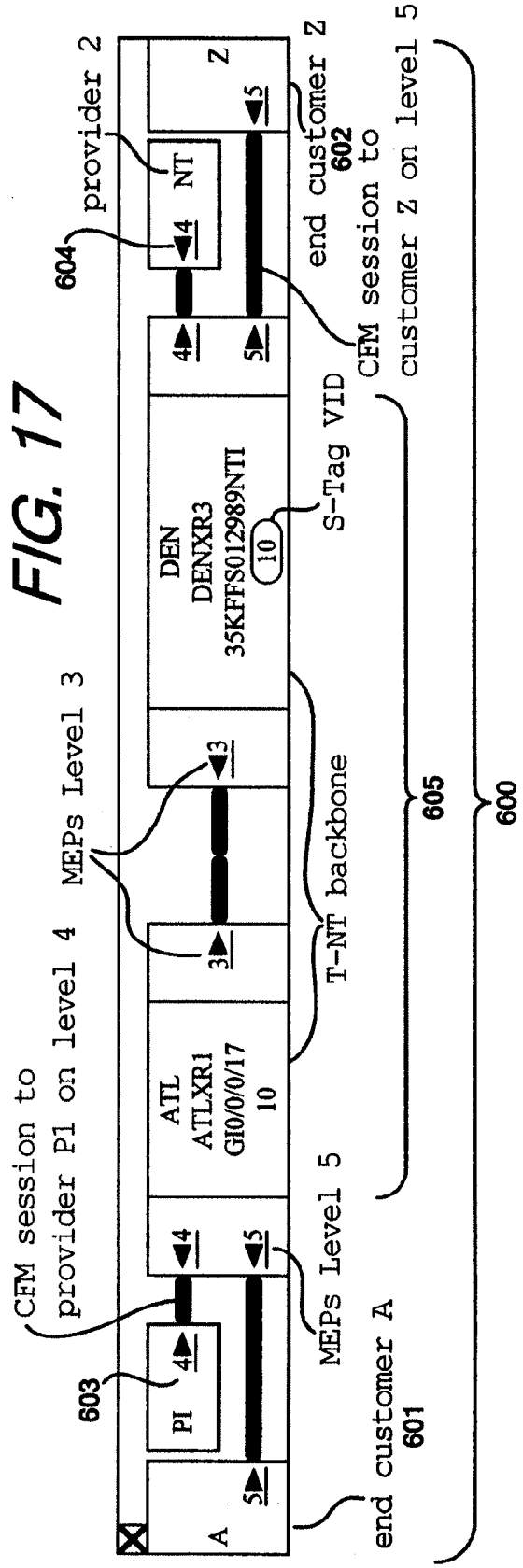

CFM session to
provider P1 on level 4
MEPs Level 3
MEPs Level 5
end customer A
T-NT backbone
S-Tag VID
CFM session to
customer Z on level 5
end customer Z
provider 2
A
PI
ATL
ATLXR1
GI0/0/0/17
10
DEN
DENXR3
35KFFS012989NTI
10
NT
Z
601
602
603
604
605
600

FIG. 17

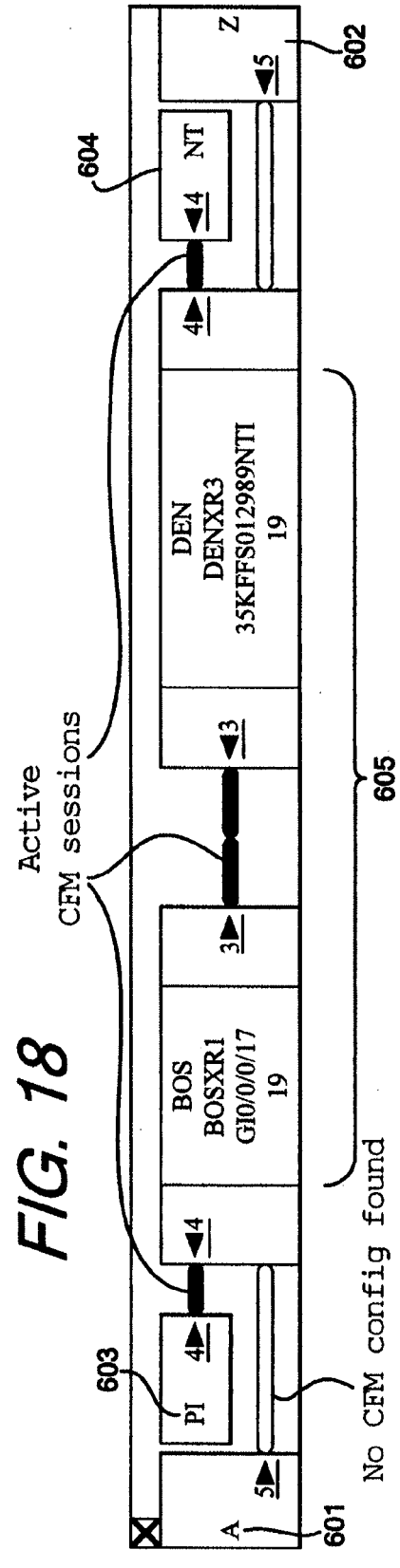

Active
CFM sessions
No CFM config found
A
PI
BOS
BOSXR1
GI0/0/0/17
19
DEN
DENXR3
35KFFS012989NTI
19
NT
Z
601
602
603
604
605

FIG. 18

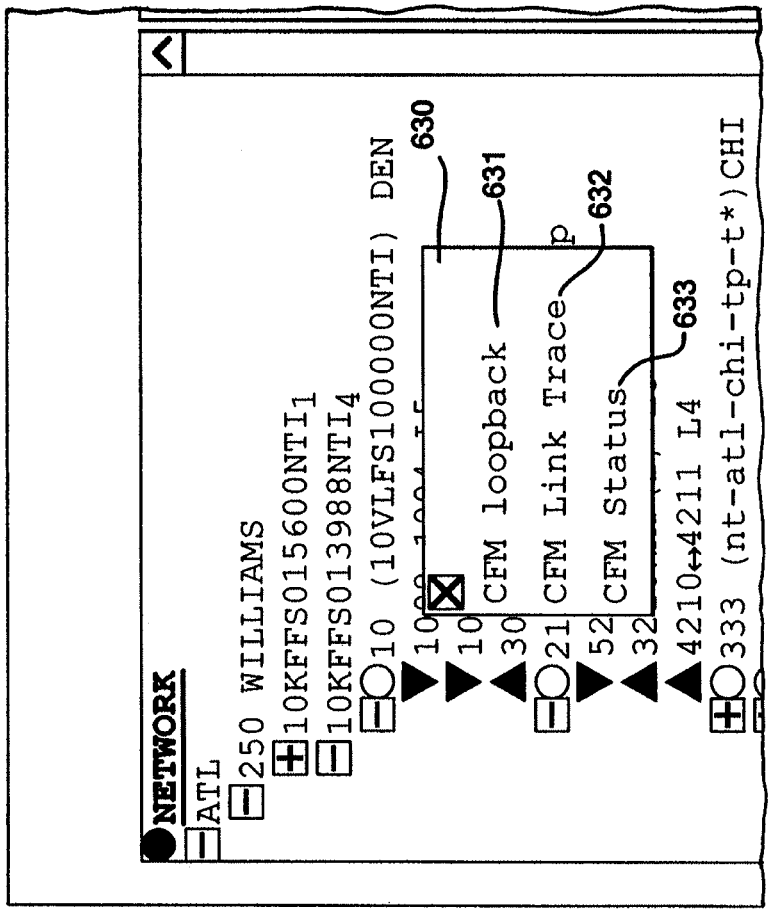

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
10 (10VLFS100000NTI) DEN
CFM loopback
CFM Link Trace
CFM Status
4210↔4211 L4
333 (nt-atl-chi-tp-t*)CHI
630
631
632
633

FIG. 19

FIG. 20

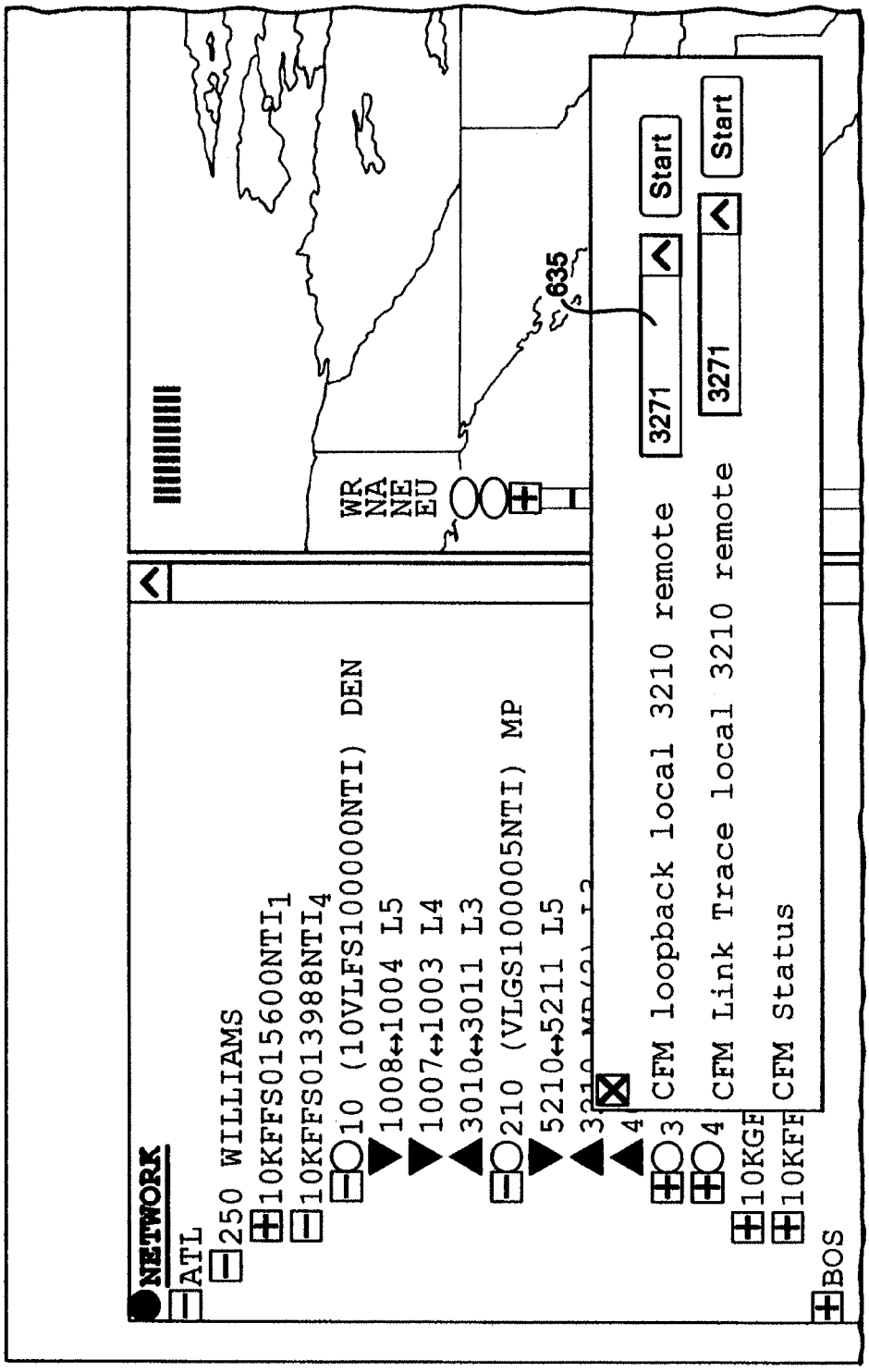

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
10 (10VLFS100000NTI) DEN
1008↔1004 L5
1007↔1003 L4
3010↔3011 L3
210 (VLGS100005NTI) MP
5210↔5211 L5
4
3 CFM loopback local 3210 remote
4 CFM Link Trace local 3210 remote
10KGF
10KFF CFM Status
BOS
WR
NA
NE
EU
635
3271
Start
3271
Start

FIG. 21

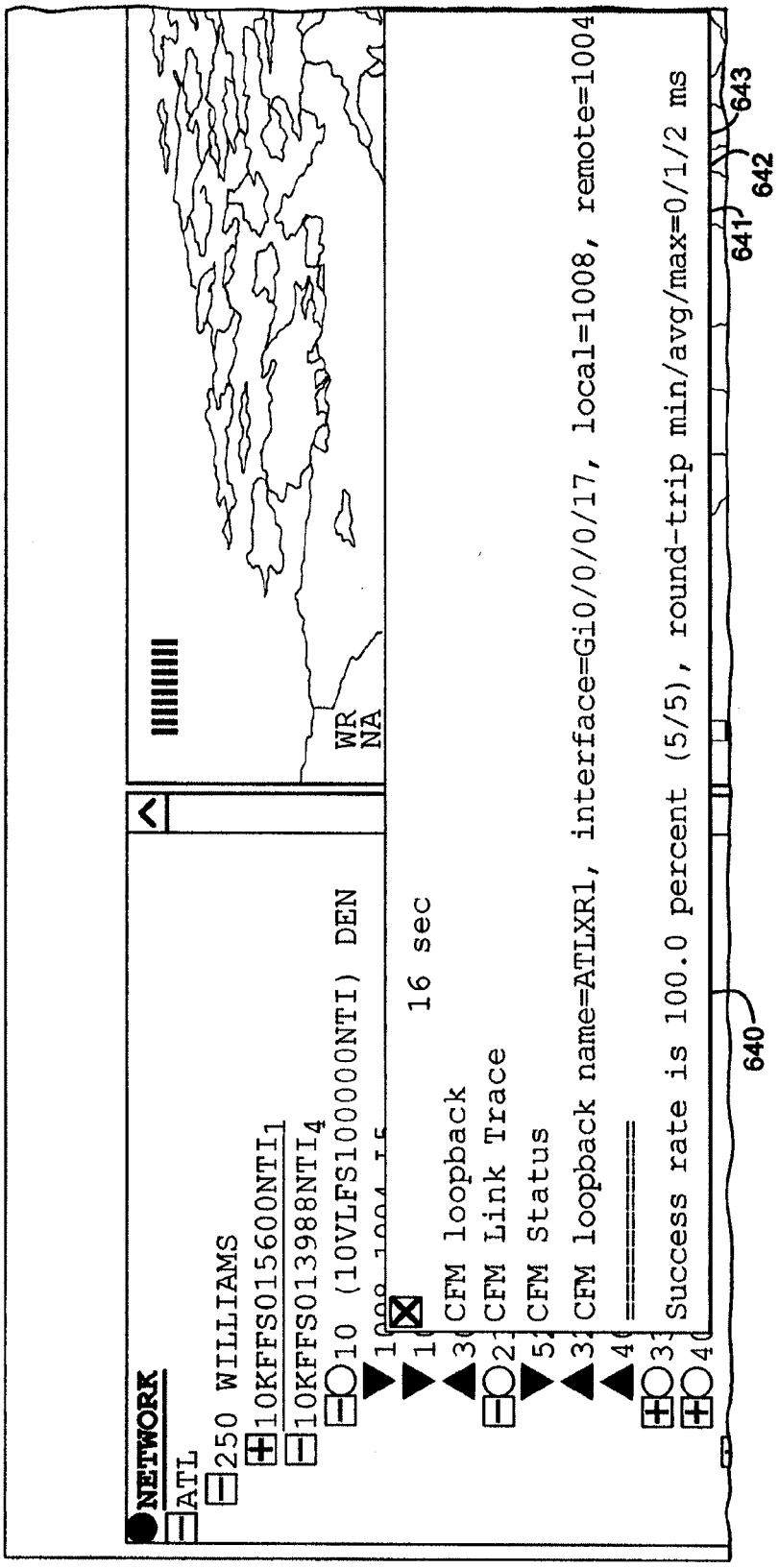

NETWORK
ATL
250 WILLIAMS
10KFFS01560NTI1
10KFFS013988NTI4
10 (10VLFS1000000NTI) DEN
WR
NA
16 sec
CFM loopback
CFM Link Trace
CFM Status
CFM loopback name=ATLXR1, interface=Gi0/0/0/17, local=1008, remote=1004
Success rate is 100.0 percent (5/5), round-trip min/avg/max=0/1/2 ms
640
641
642
643

FIG. 22

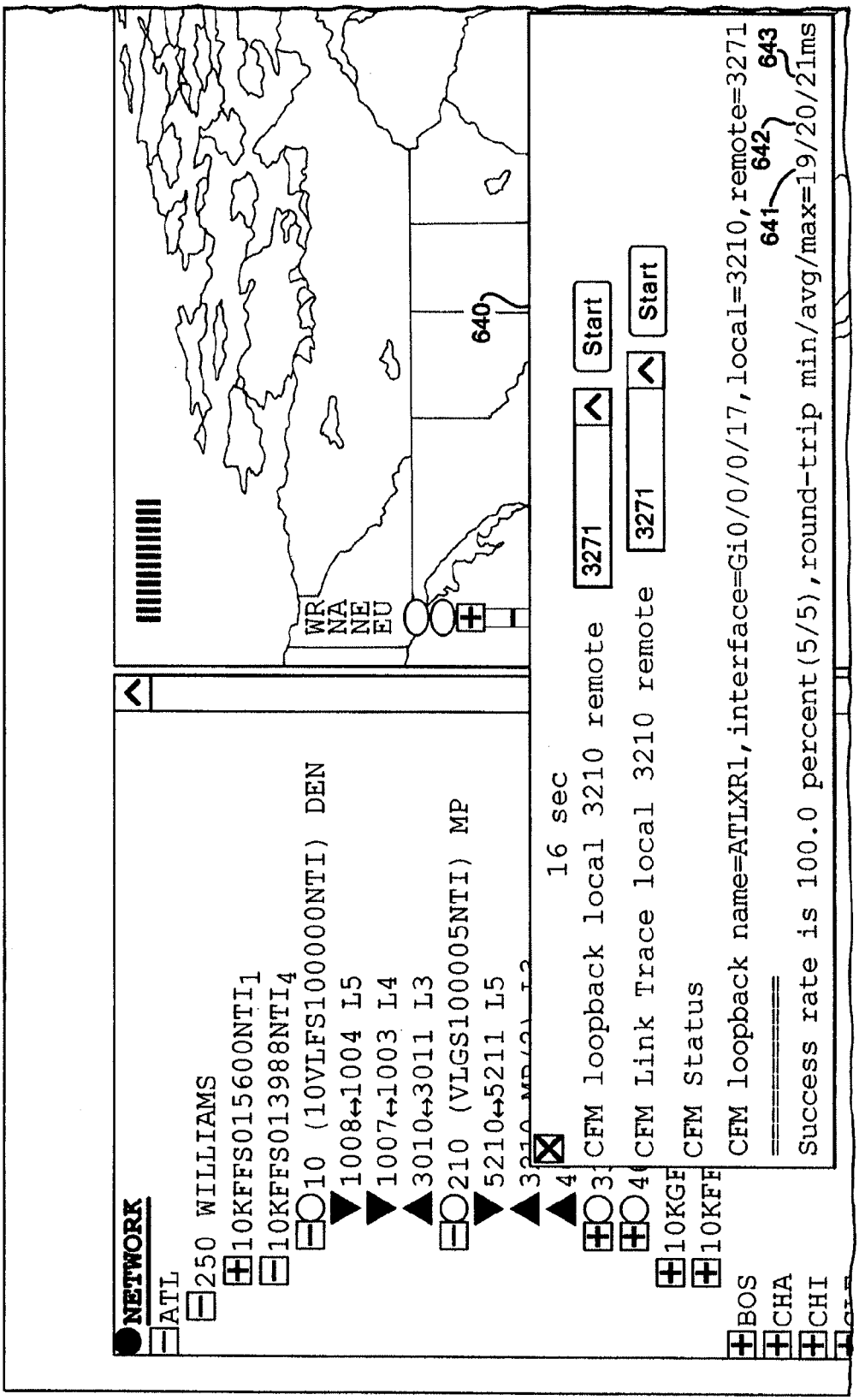

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
10 (10VLFS100000NTI) DEN
1008↔1004 L5
1007↔1003 L4
3010↔3011 L3
210 (VLGS100005NTI) MP
5210↔5211 L5
BOS
CHA
CHI
WR
NA
NE
EU
640
16 sec
CFM loopback local 3210 remote
3271
Start
CFM Link Trace local 3210 remote
3271
Start
CFM Status
CFM loopback name=ATLXR1,interface=Gi0/0/0/17,local=3210,remote=3271
641
642
643
Success rate is 100.0 percent(5/5),round-trip min/avg/max=19/20/21ms

FIG. 23

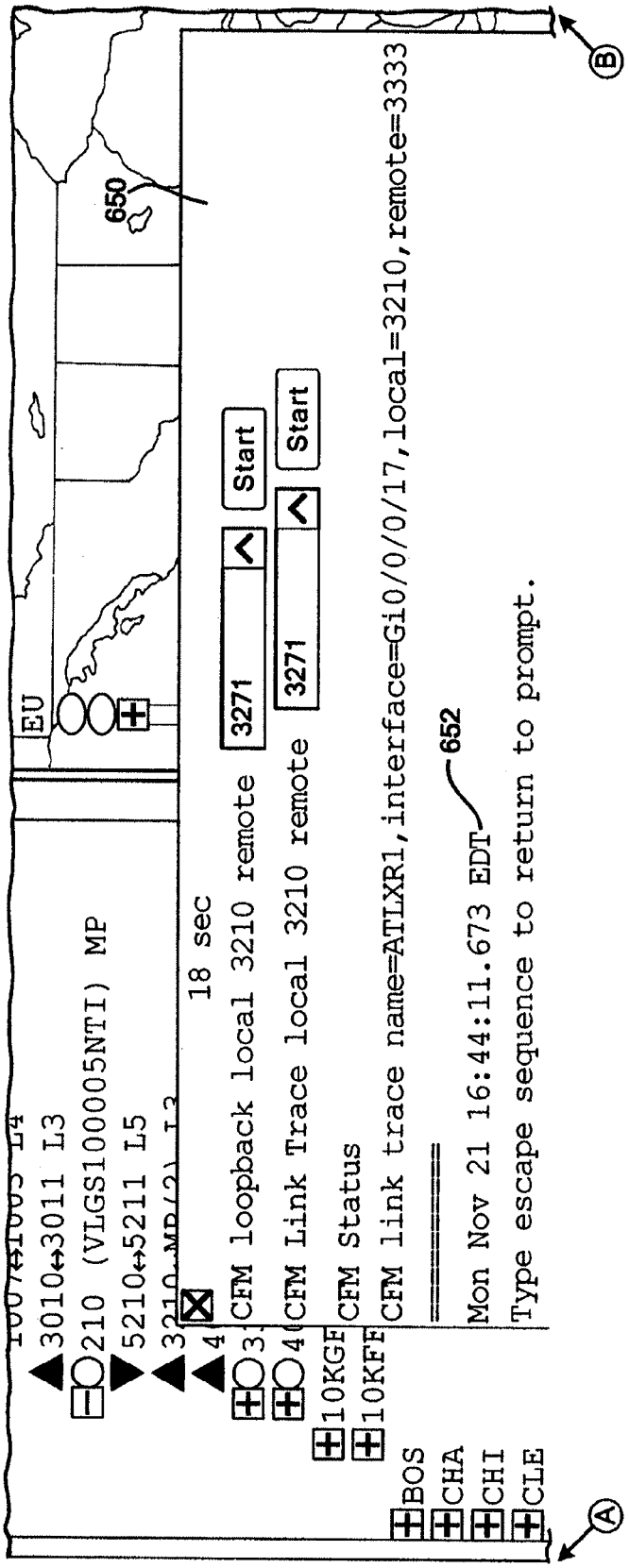

650
EU
3010↔3011 L3
210 (VLGS100005NTI) MP
5210↔5211 L5
18 sec
CFM loopback local 3210 remote
3271
Start
CFM Link Trace local 3210 remote
3271
Start
CFM Status
CFM link trace name=ATLXR1,interface=Gi0/0/0/17,local=3210,remote=3333
652
Mon Nov 21 16:44:11.673 EDT
Type escape sequence to return to prompt.
10KGF
10KFF
BOS
CHA
CHI
CLE
A
B

FIG. 23

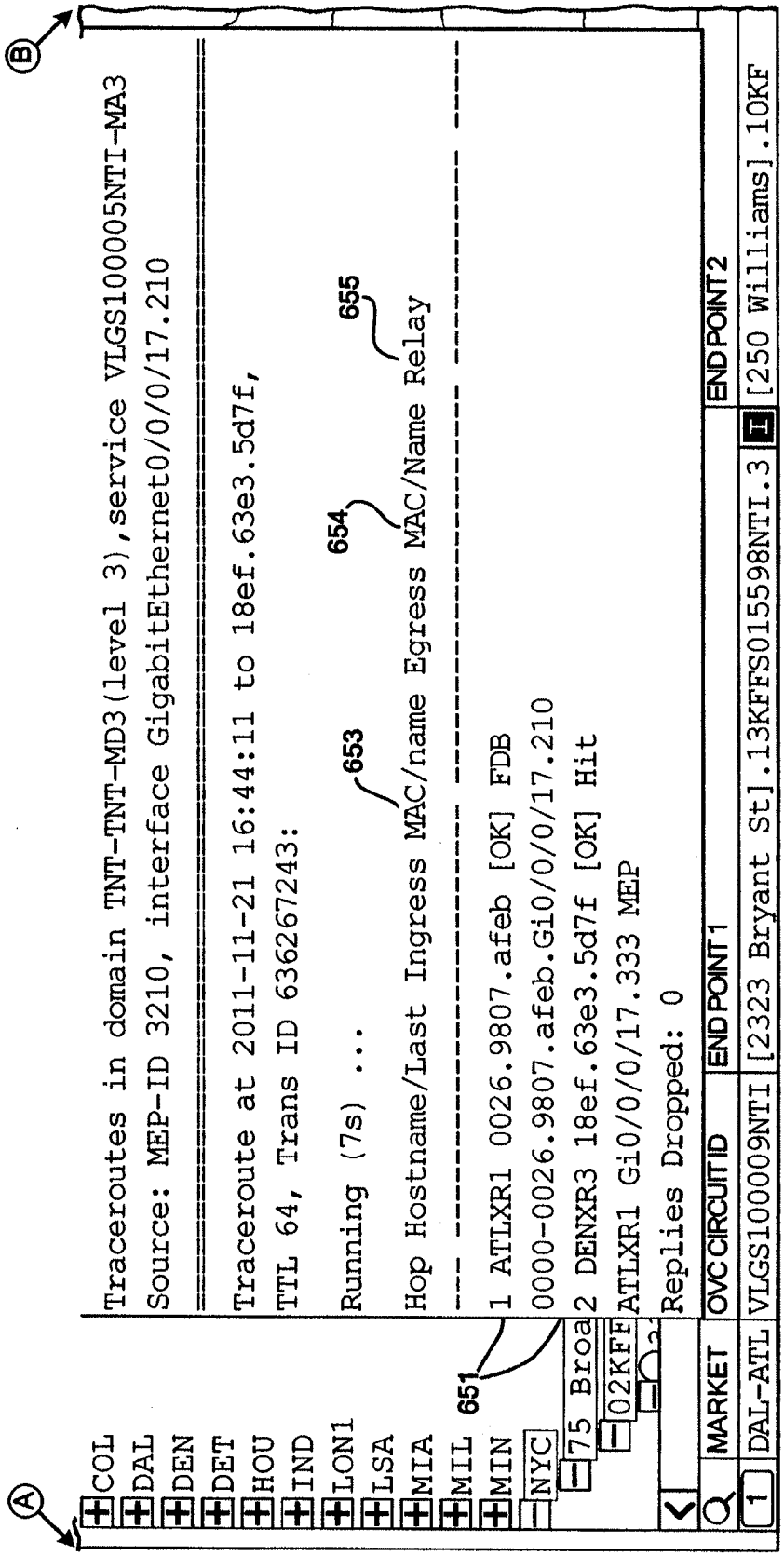

A
B
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
MIN
NYC
75 Broa
02KFF
651
Traceroutes in domain TNT-TNT-MD3(level 3),service VLGS100005NTI-MA3
Source: MEP-ID 3210, interface GigabitEthernet0/0/0/17.210
Traceroute at 2011-11-21 16:44:11 to 18ef.63e3.5d7f,
TTL 64, Trans ID 636267243:
Running (7s) ...
653
654
655
Hop Hostname/Last Ingress MAC/name Egress MAC/Name Relay
1 ATLXR1 0026.9807.afeb [OK] FDB
0000-0026.9807.afeb.Gi0/0/0/17.210
2 DENXR3 18ef.63e3.5d7f [OK] Hit
ATLXR1 Gi0/0/0/17.333 MEP
Replies Dropped: 0
MARKET
OVC CIRCUIT ID
END POINT 1
END POINT 2
DAL-ATL
VLGS100009NTI
[2323 Bryant St].13KFFS015598NTI.3
[250 Williams].10KF

FIG. 24

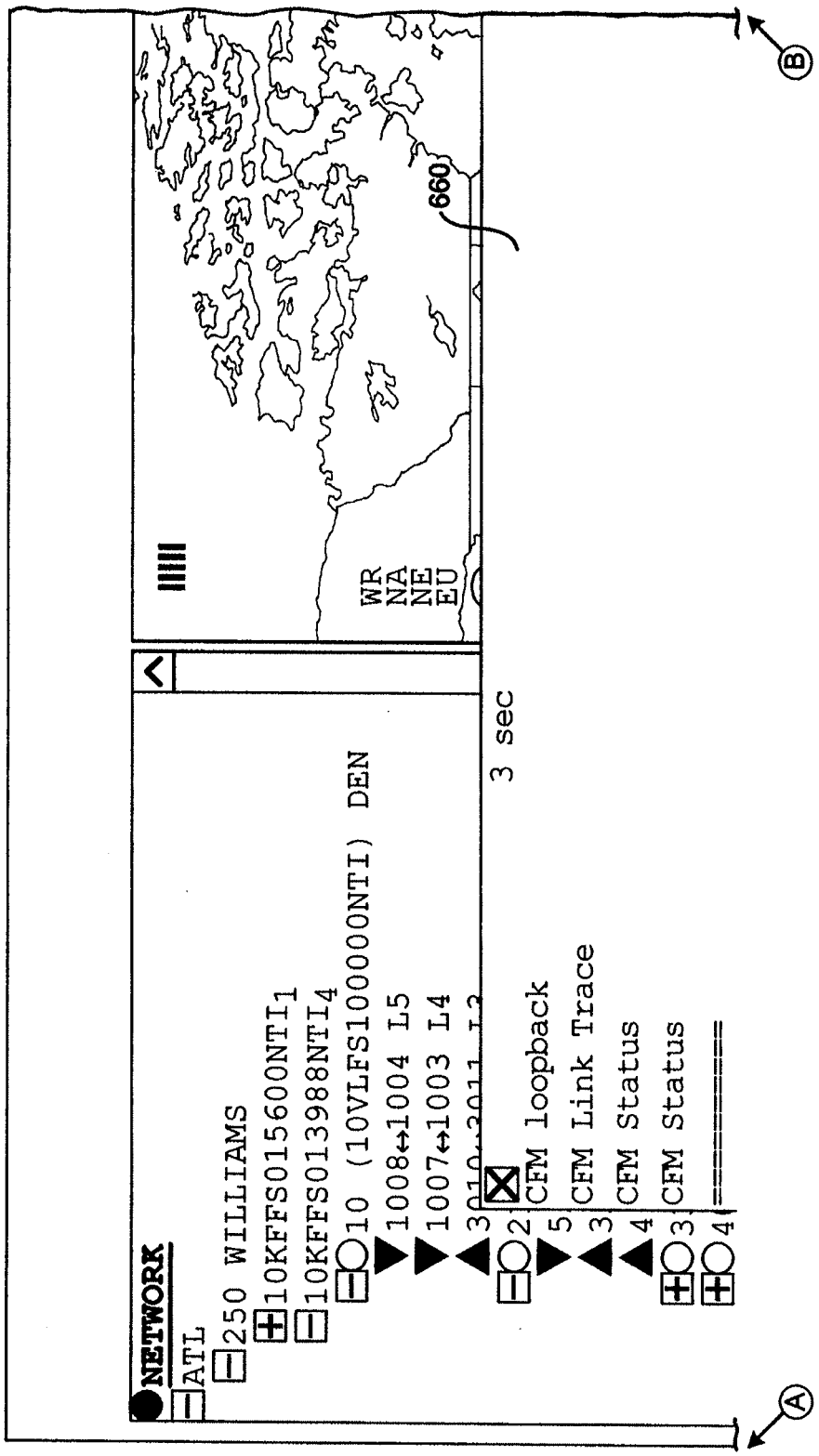

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI1
10KFFS013988NTI4
10 (10VLFS100000NTI) DEN
1008↔1004 L5
1007↔1003 L4
3
2
CFM loopback
5
CFM Link Trace
3
CFM Status
4
3
CFM Status
4
3 sec
660
WR
NA
NE
EU
A
B

FIG. 24

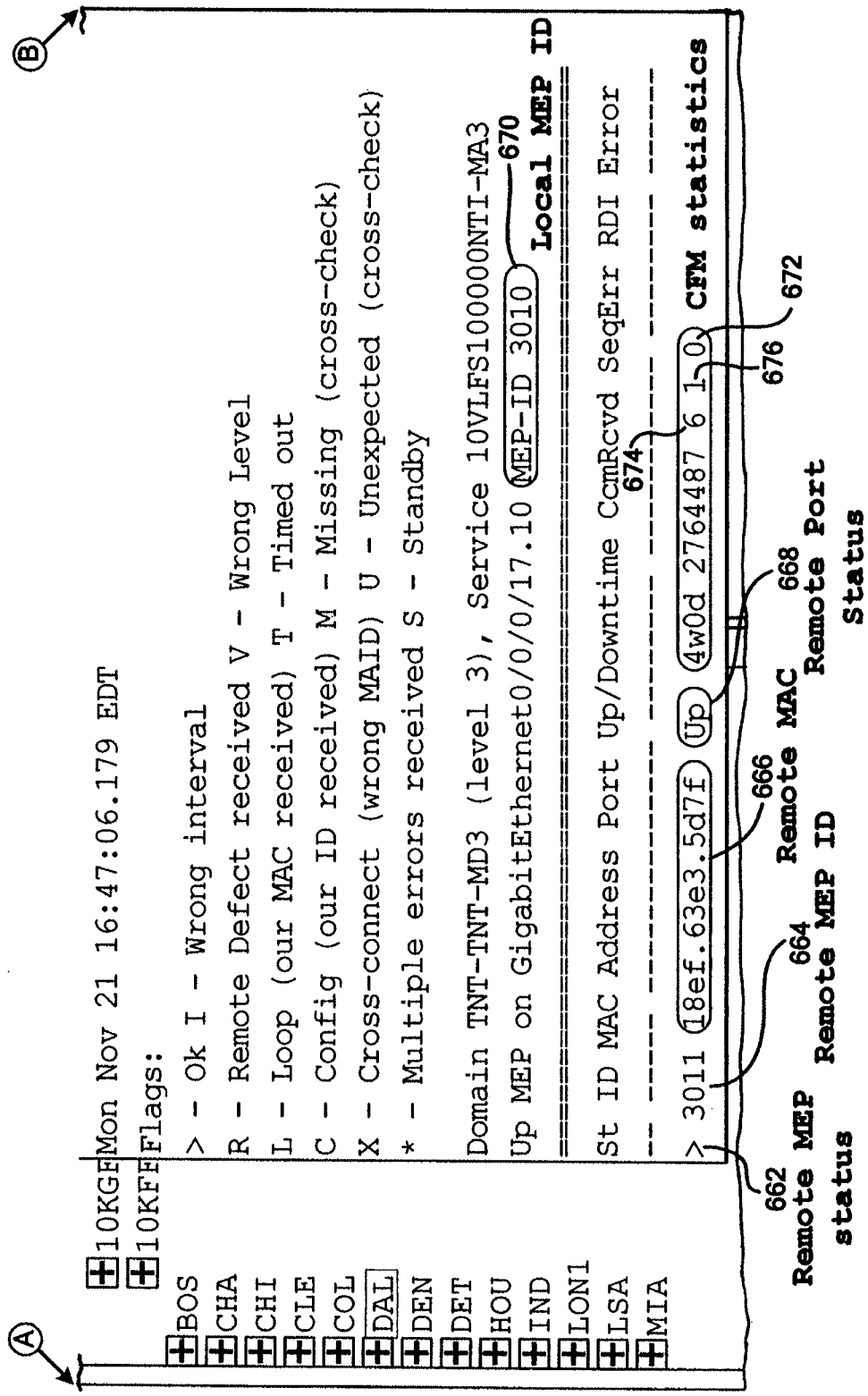

A
B
10KGE Mon Nov 21 16:47:06.179 EDT
10KFE Flags:
> - Ok I - Wrong interval
R - Remote Defect received V - Wrong Level
L - Loop (our MAC received) T - Timed out
C - Config (our ID received) M - Missing (cross-check)
X - Cross-connect (wrong MAID) U - Unexpected (cross-check)
* - Multiple errors received S - Standby
Domain TNT-TNT-MD3 (level 3), Service 10VLFS100000NTI-MA3
Up MEP on GigabitEthernet0/0/0/17.10 MEP-ID 3010
Local MEP ID
670
St ID MAC Address Port Up/Downtime CcmRcvd SeqErr RDI Error
674
> 3011 18ef.63e3.5d7f Up 4w0d 2764487 6 1 0
CFM statistics
672
676
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
662
Remote MEP status
664
Remote MEP ID
666
Remote MAC
668
Remote Port Status

FIG. 25

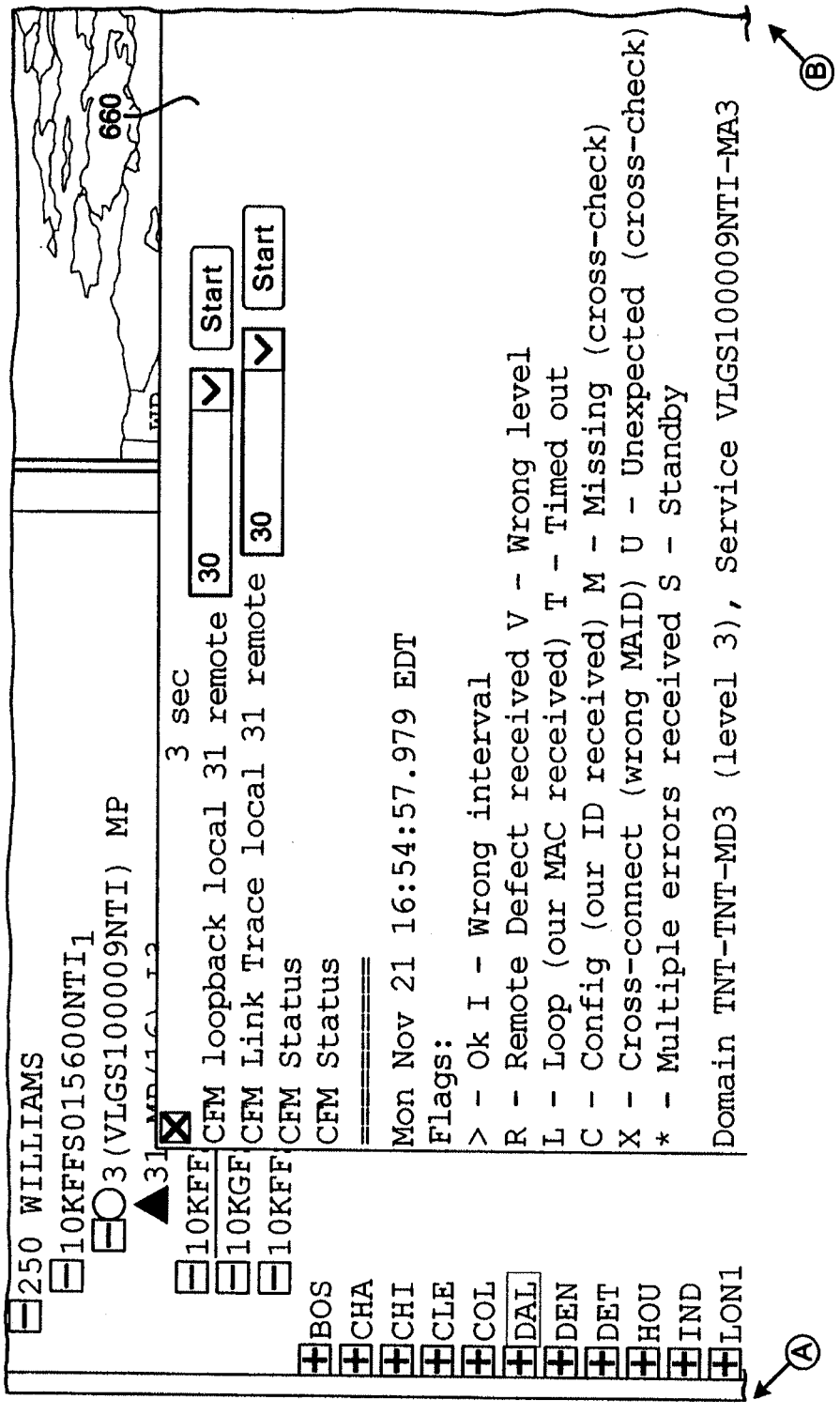

250 WILLIAMS
10KFFS015600NTI1
3(VLGS100009NTI) MP
31
10KFF
10KGF
10KFF
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
660
3 sec
CFM loopback local 31 remote
30
Start
CFM Link Trace local 31 remote
30
Start
CFM Status
CFM Status
Mon Nov 21 16:54:57.979 EDT
Flags:
> - Ok I - Wrong interval
R - Remote Defect received V - Wrong level
L - Loop (our MAC received) T - Timed out
C - Config (our ID received) M - Missing (cross-check)
X - Cross-connect (wrong MAID) U - Unexpected (cross-check)
* - Multiple errors received S - Standby
Domain TNT-TNT-MD3 (level 3), Service VLGS100009NTI-MA3
A
B

FIG. 25

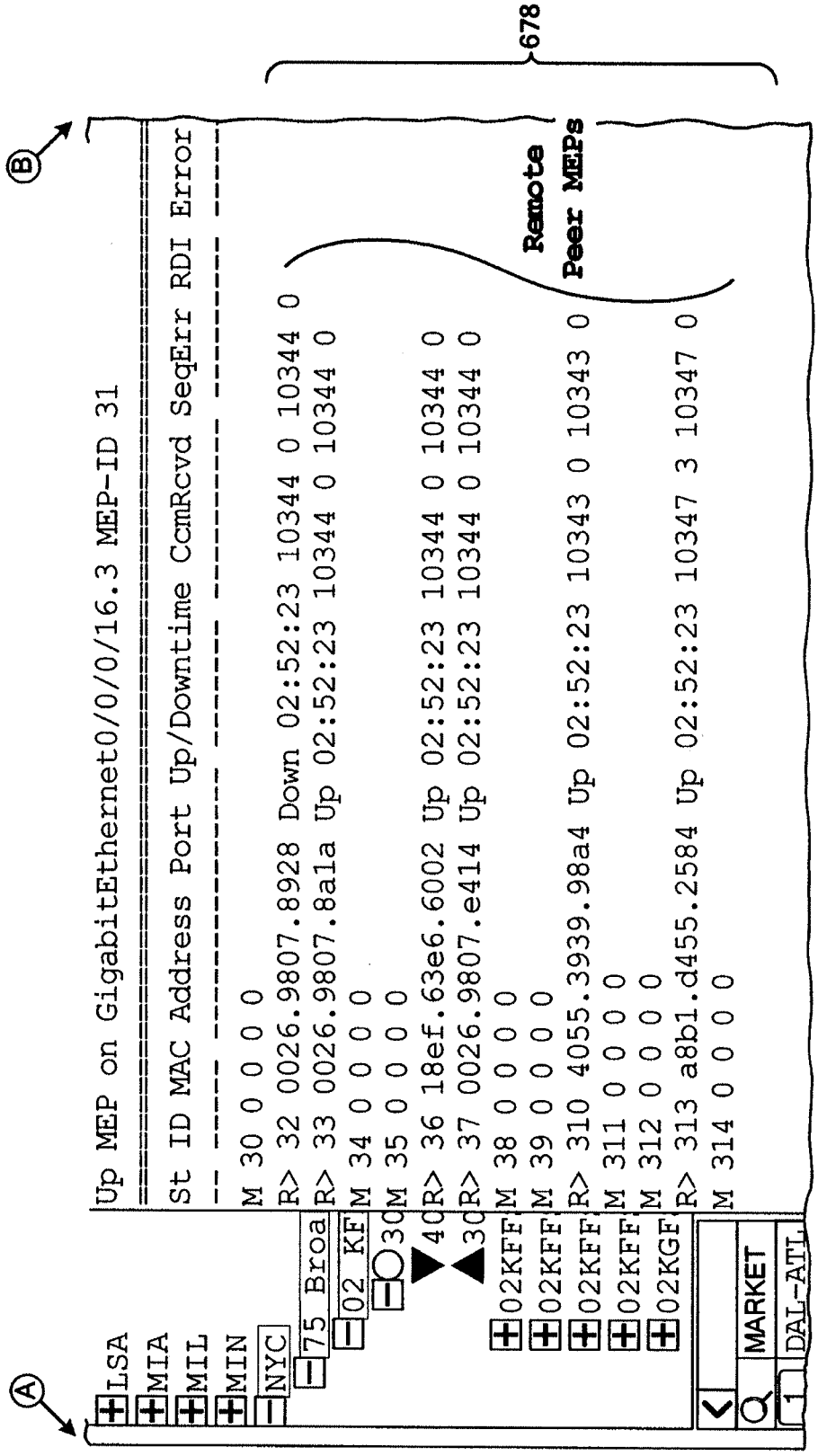
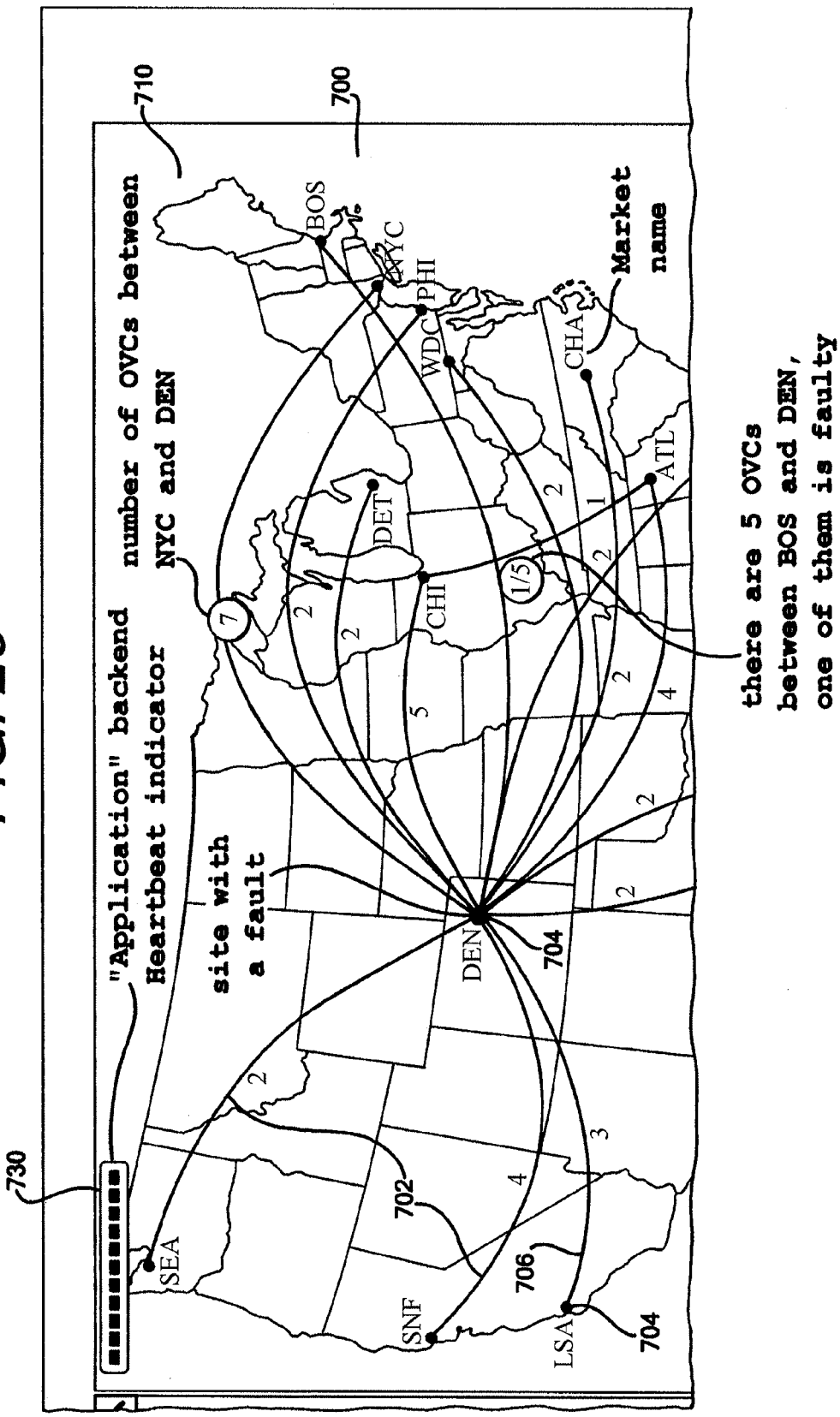

678
Remote
Peer MEPs
Up MEP on GigabitEthernet0/0/0/16.3 MEP-ID 31
St ID MAC Address Port Up/Downtime CcmRcvd SeqErr RDI Error
M 30 0 0 0 0 0
R> 32 0026.9807.8928 Down 02:52:23 10344 0 10344 0
R> 33 0026.9807.8a1a Up 02:52:23 10344 0 10344 0
M 34 0 0 0 0 0
M 35 0 0 0 0 0
R> 36 18ef.63e6.6002 Up 02:52:23 10344 0 10344 0
R> 37 0026.9807.e414 Up 02:52:23 10344 0 10344 0
M 38 0 0 0 0 0
M 39 0 0 0 0 0
R> 310 4055.3939.98a4 Up 02:52:23 10343 0 10343 0
M 311 0 0 0 0 0
M 312 0 0 0 0 0
R> 313 a8b1.d455.2584 Up 02:52:23 10347 3 10347 0
M 314 0 0 0 0 0
LSA
MIA
MIL
MIN
NYC
75 Broa
02 KF
02KFF
02KFF
02KFF
02KFF
02KGF
MARKET
DAL-ATL
A
B

FIG. 26


730
710
700
"Application" backend Heartbeat indicator
site with a fault
number of OVCs between NYC and DEN
Market name
there are 5 OVCs between BOS and DEN, one of them is faulty
BOS
NYC
PHI
WDC
CHA
ATL
DET
CHI
DEN
SEA
SNF
LSA
702
704
706
704
7
1/5

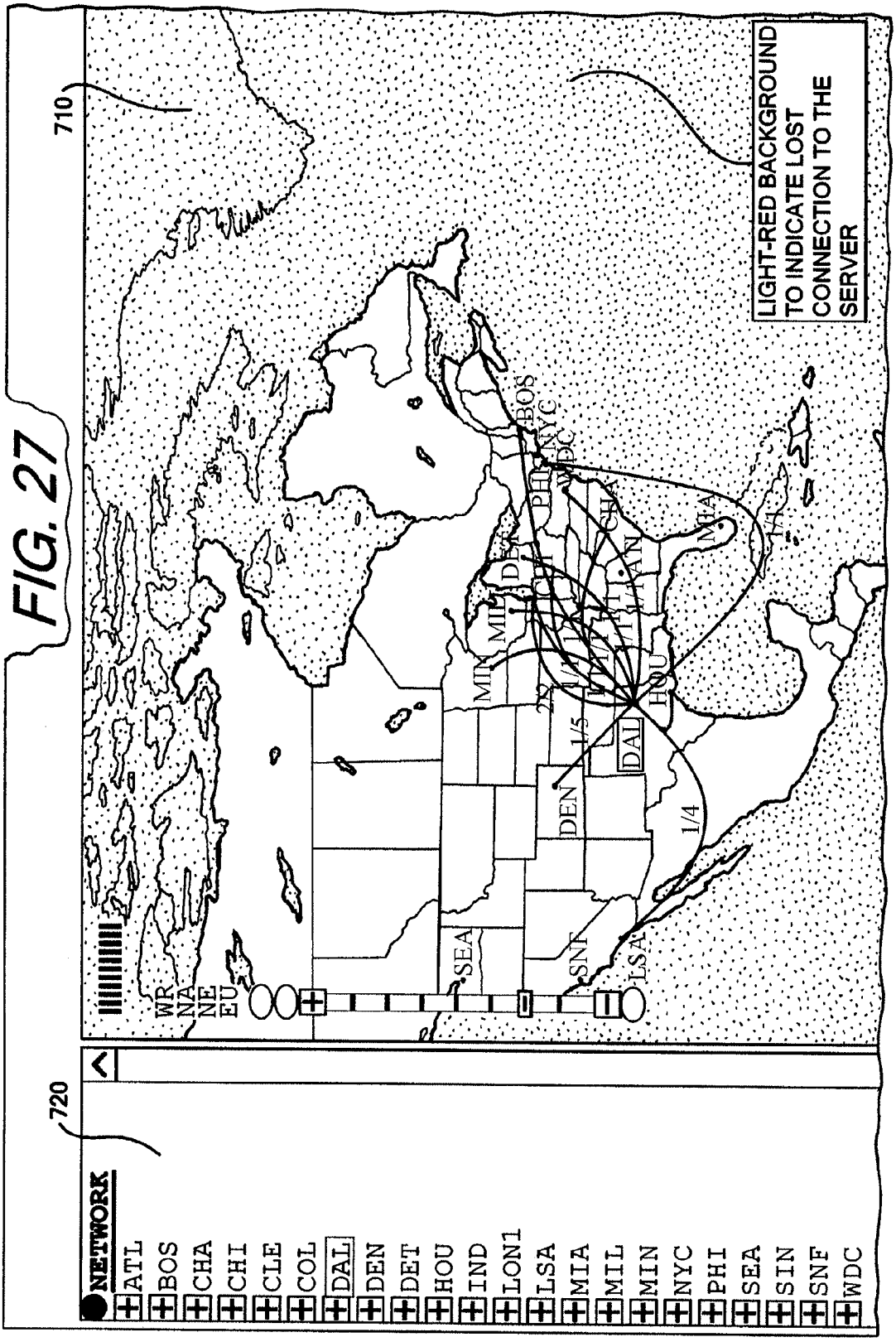


FIG. 27
710
720
NETWORK
ATL
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
MIN
NYC
PHI
SEA
SIN
SNF
WDC
WR
NA
NE
EU
LIGHT-RED BACKGROUND TO INDICATE LOST CONNECTION TO THE SERVER
1/4
1/5

FIG. 28

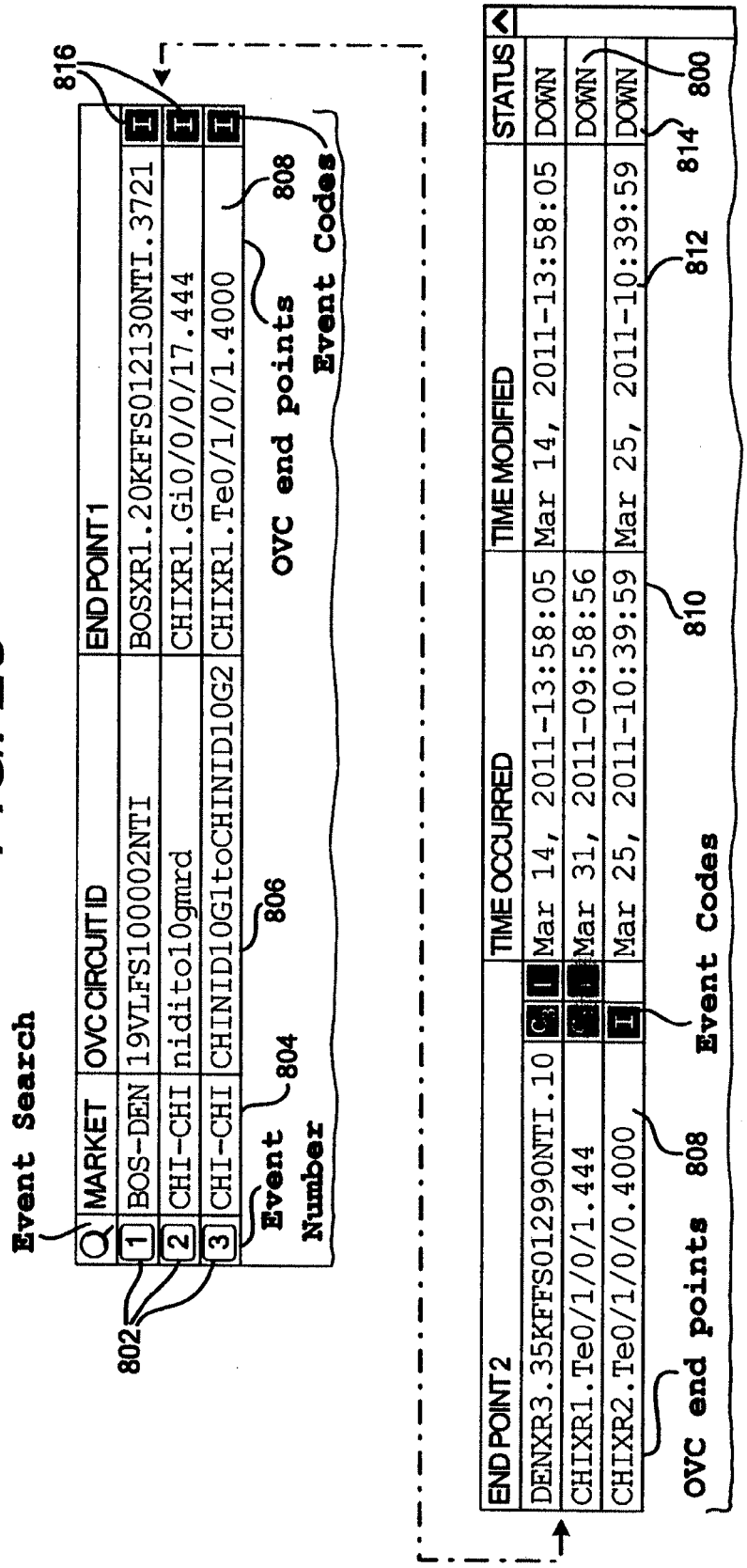

Event Search
MARKET
OVC CIRCUIT ID
END POINT 1
1 BOS-DEN 19VLFS100002NTI BOSXR1.20KFFS012130NTI.3721
2 CHI-CHI nidito10gmrd CHIXR1.Gi0/0/0/17.444
3 CHI-CHI CHINID10G1toCHINID10G2 CHIXR1.Te0/1/0/1.4000
802
804
Event Number
806
OVC end points
808
Event Codes
816
END POINT 2
TIME OCCURRED
TIME MODIFIED
STATUS
DENXR3.35KFFS012990NTI.10 Mar 14, 2011-13:58:05 Mar 14, 2011-13:58:05 DOWN
CHIXR1.Te0/1/0/1.444 Mar 31, 2011-09:58:56 DOWN
CHIXR2.Te0/1/0/0.4000 Mar 25, 2011-10:39:59 Mar 25, 2011-10:39:59 DOWN
OVC end points
808
Event Codes
810
812
814
800

FIG. 29

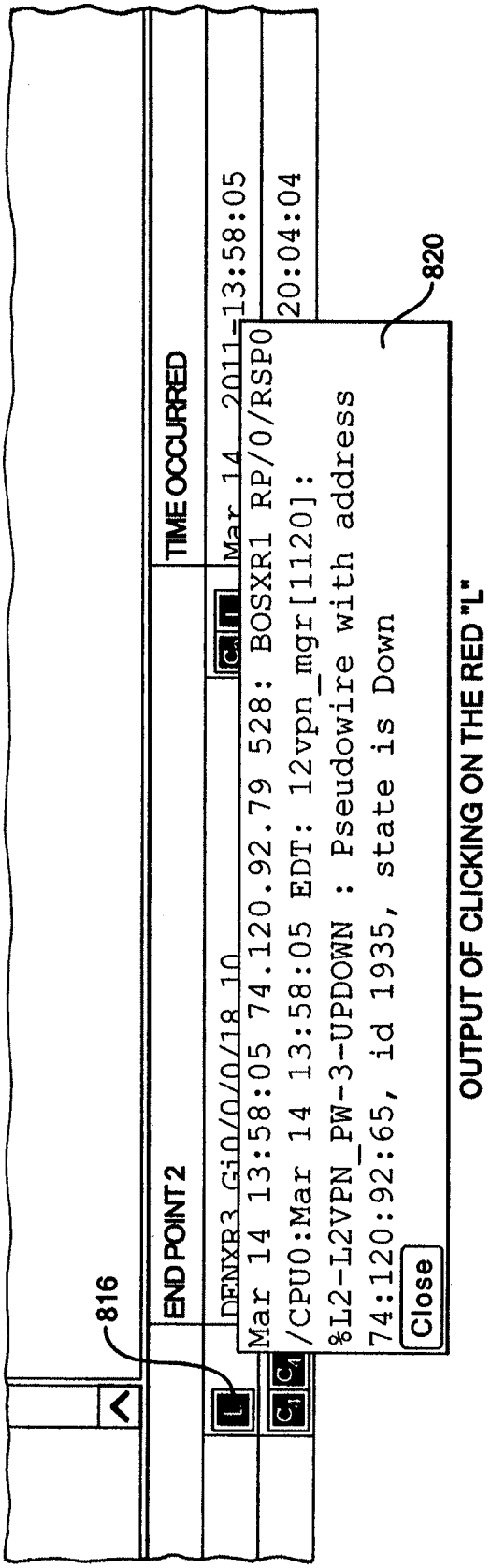

816
END POINT 2
TIME OCCURRED
DENXR3 Gi0/0/0/18 10
Mar 14 2011 13:58:05
Mar 14 13:58:05 74.120.92.79 528: BOSXR1 RP/0/RSP0
/CPU0:Mar 14 13:58:05 EDT: l2vpn_mgr[1120]:
%L2-L2VPN_PW-3-UPDOWN : Pseudowire with address
74:120:92:65, id 1935, state is Down
20:04:04
Close
820
OUTPUT OF CLICKING ON THE RED "L"

FIG. 30

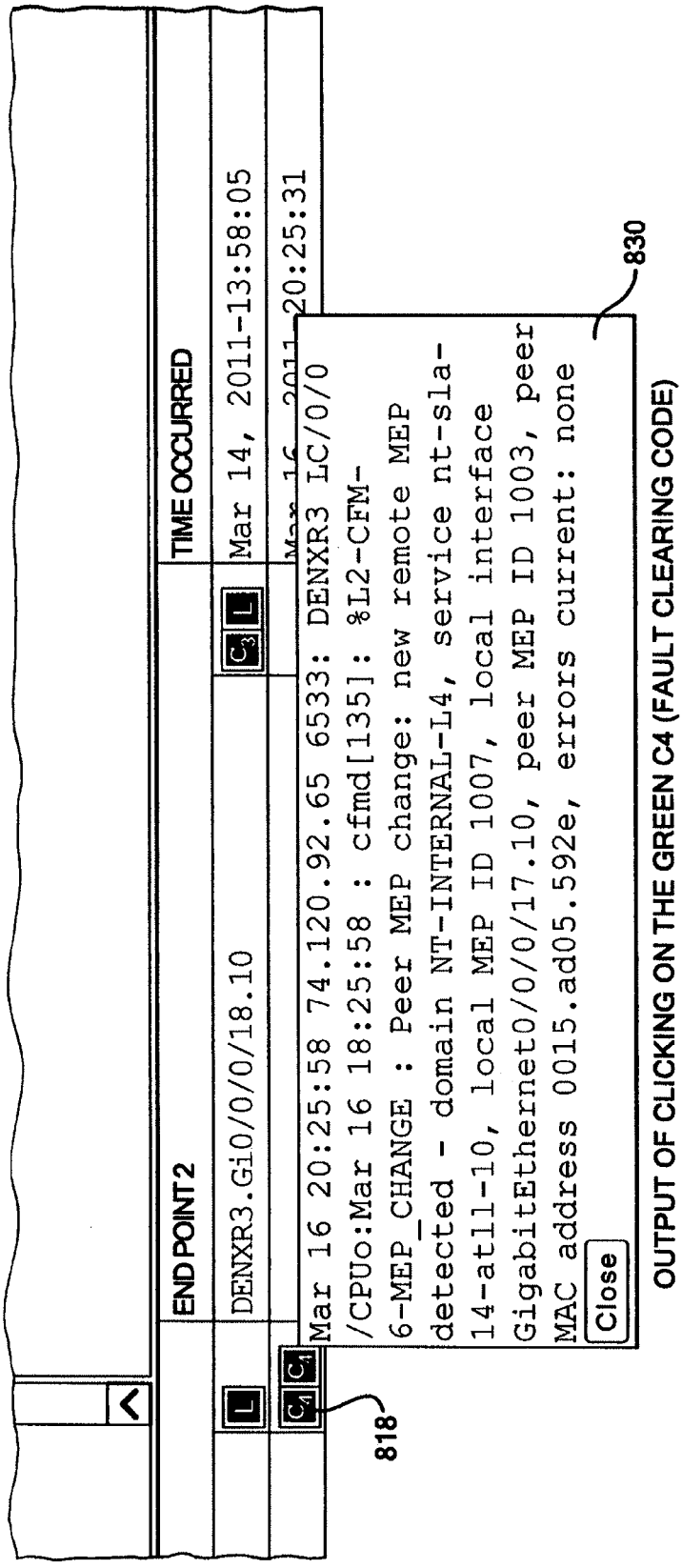

ENDPOINT2
TIME OCCURRED
DENXR3.Gi0/0/0/18.10
Mar 14, 2011-13:58:05
Mar 16 20:25:58 74.120.92.65 6533: DENXR3 LC/0/0
/CPU0:Mar 16 18:25:58 : cfmd[135]: %L2-CFM-
6-MEP_CHANGE : Peer MEP change: new remote MEP
detected - domain NT-INTERNAL-L4, service nt-sla-
14-atll-10, local MEP ID 1007, local interface
GigabitEthernet0/0/0/17.10, peer MEP ID 1003, peer
MAC address 0015.ad05.592e, errors current: none
Close
818
830
OUTPUT OF CLICKING ON THE GREEN C4 (FAULT CLEARING CODE)

FIG. 31

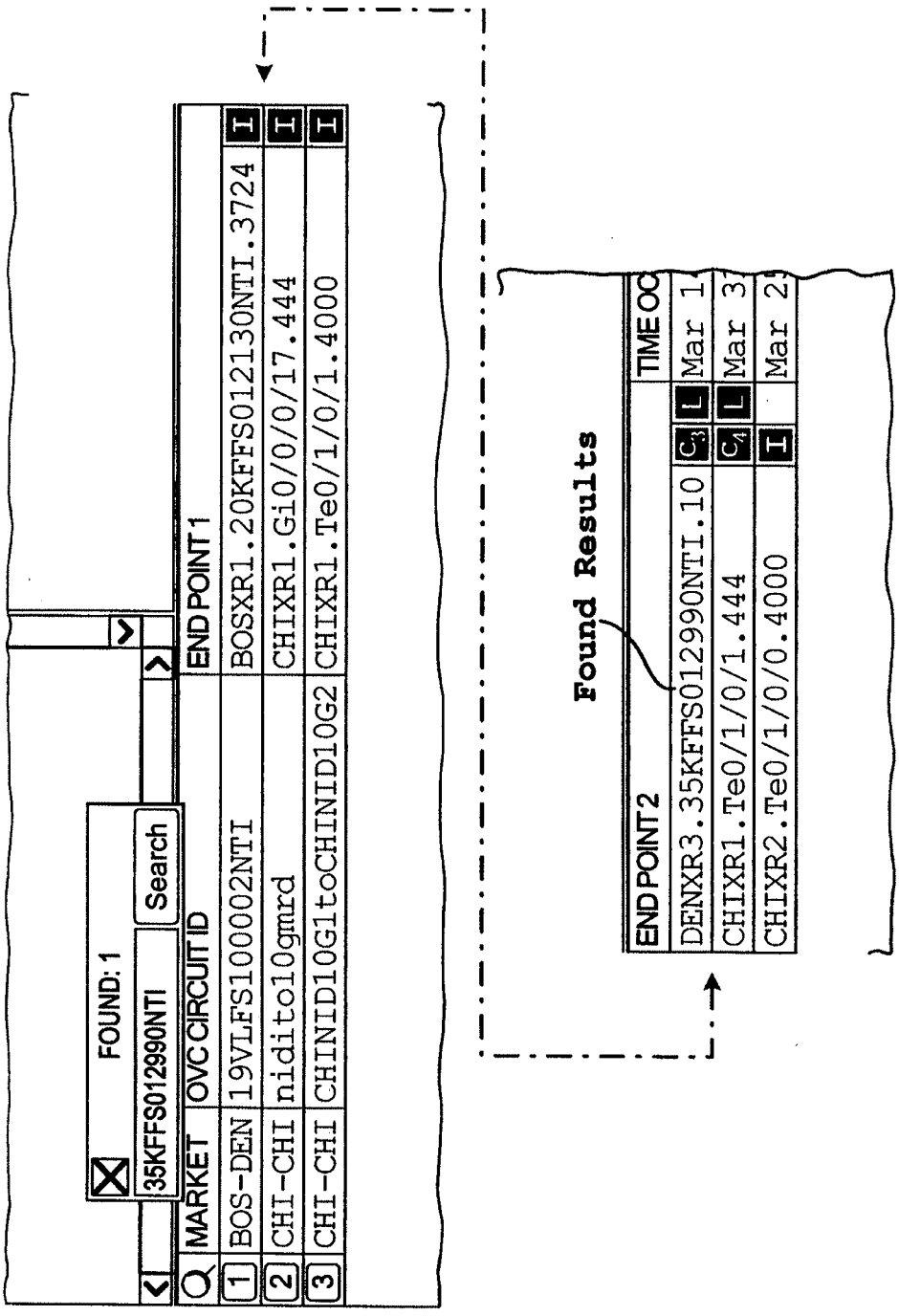

FOUND: 1
35KFFS012990NTI
Search
MARKET
OVC CIRCUIT ID
END POINT 1
1 BOS-DEN 19VLFS100002NTI BOSXR1.20KFFS012130NTI.3724 I
2 CHI-CHI nidito10gmrd CHIXR1.Gi0/0/0/17.444 I
3 CHI-CHI CHINID10G1toCHINID10G2 CHIXR1.Te0/1/0/1.4000 I
Found Results
END POINT 2
TIME OC
DENXR3.35KFFS012990NTI.10 C3 L Mar 1
CHIXR1.Te0/1/0/1.444 C4 L Mar 3
CHIXR2.Te0/1/0/0.4000 I Mar 2

FIG. 32

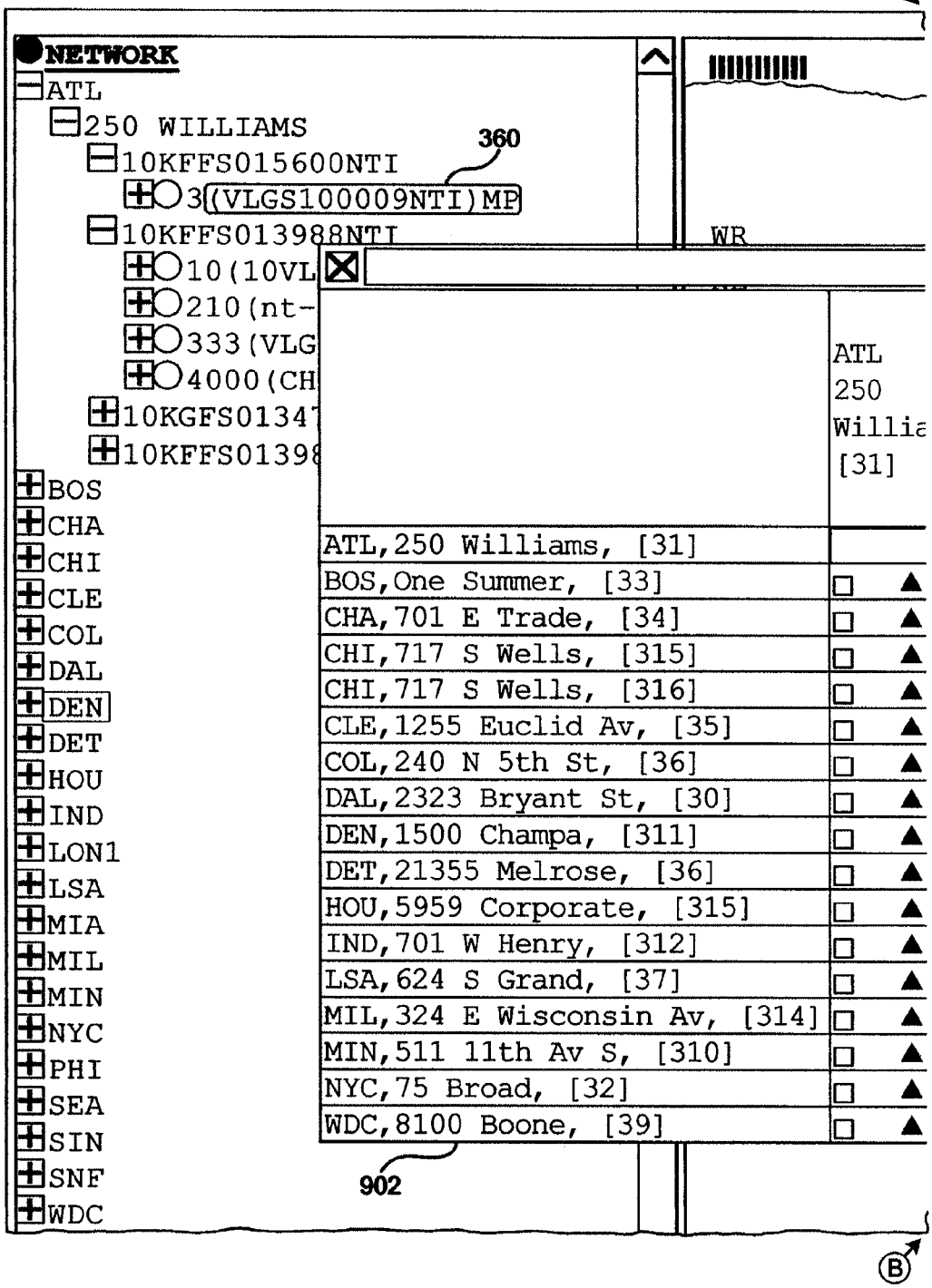

NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI
3(VLGS100009NTI)MP
10KFFS013988NTI
10(10VL
210(nt-
333(VLG
4000(CH
10KGFS0134
10KFFS0139
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
MIN
NYC
PHI
SEA
SIN
SNF
WDC
360
WR
ATL
250
Willia
[31]
ATL,250 Williams, [31]
BOS,One Summer, [33]
CHA,701 E Trade, [34]
CHI,717 S Wells, [315]
CHI,717 S Wells, [316]
CLE,1255 Euclid Av, [35]
COL,240 N 5th St, [36]
DAL,2323 Bryant St, [30]
DEN,1500 Champa, [311]
DET,21355 Melrose, [36]
HOU,5959 Corporate, [315]
IND,701 W Henry, [312]
LSA,624 S Grand, [37]
MIL,324 E Wisconsin Av, [314]
MIN,511 11th Av S, [310]
NYC,75 Broad, [32]
WDC,8100 Boone, [39]
902
A
B

FIG. 32

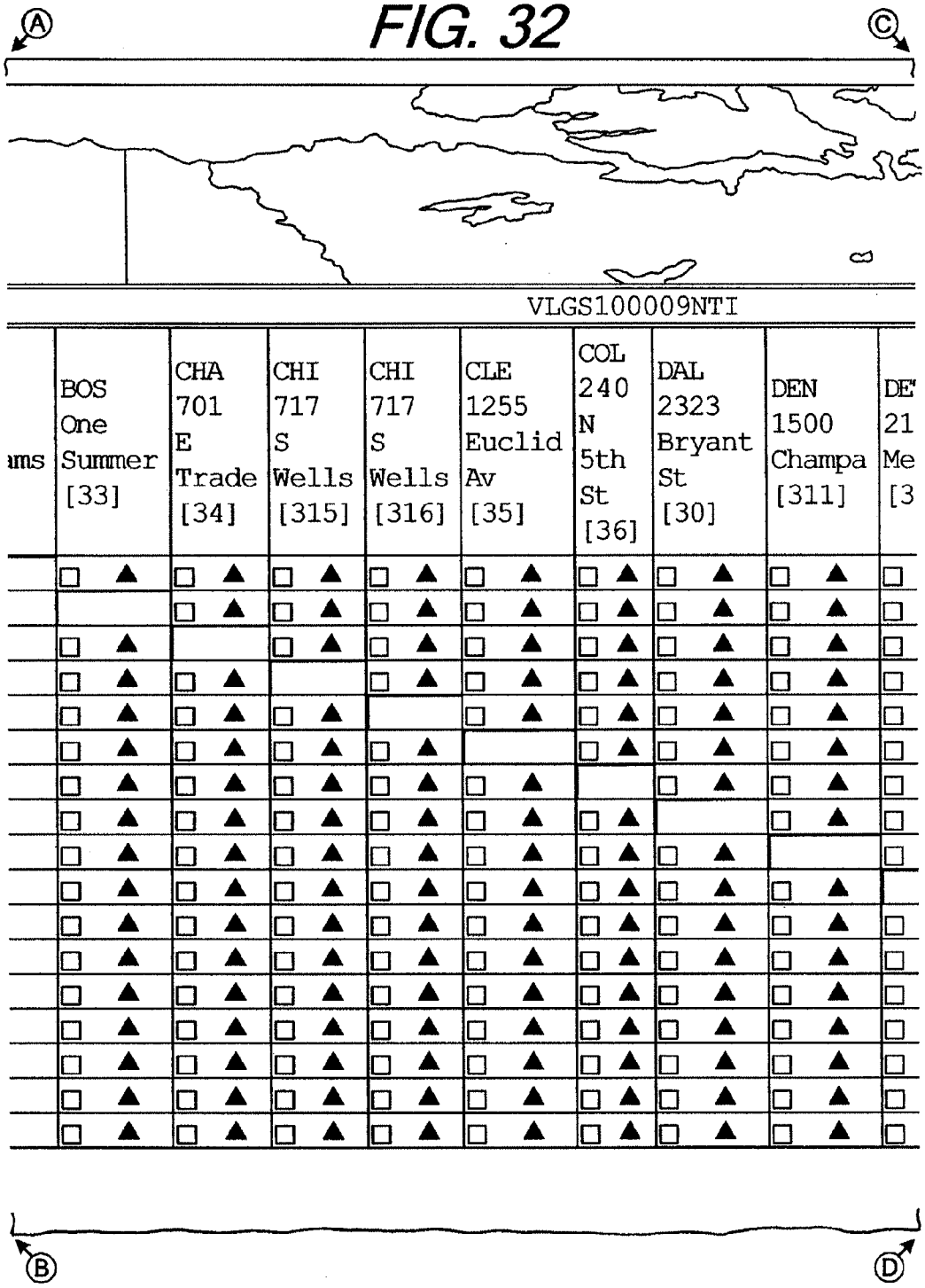

A
C
VLGS100009NTI
ıms
BOS One Summer [33]
CHA 701 E Trade [34]
CHI 717 S Wells [315]
CHI 717 S Wells [316]
CLE 1255 Euclid Av [35]
COL 240 N 5th St [36]
DAL 2323 Bryant St [30]
DEN 1500 Champa [311]
DE 21 Me [3
B
D

FIG. 32

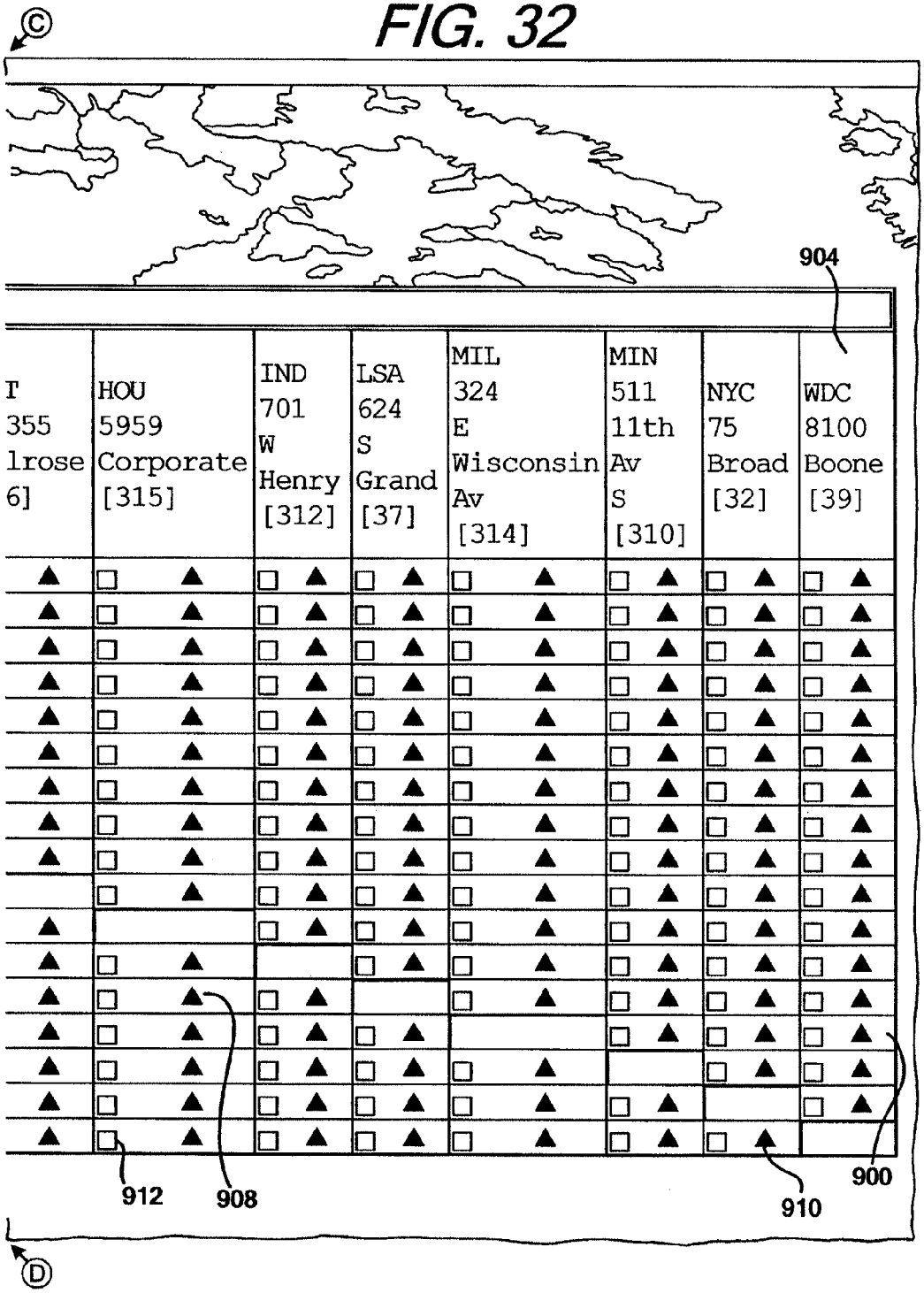

C
904
T
355
lrose
6]
HOU
5959
Corporate
[315]
IND
701
W
Henry
[312]
LSA
624
S
Grand
[37]
MIL
324
E
Wisconsin
Av
[314]
MIN
511
11th
Av
S
[310]
NYC
75
Broad
[32]
WDC
8100
Boone
[39]
912
908
910
900
D

FIG. 33

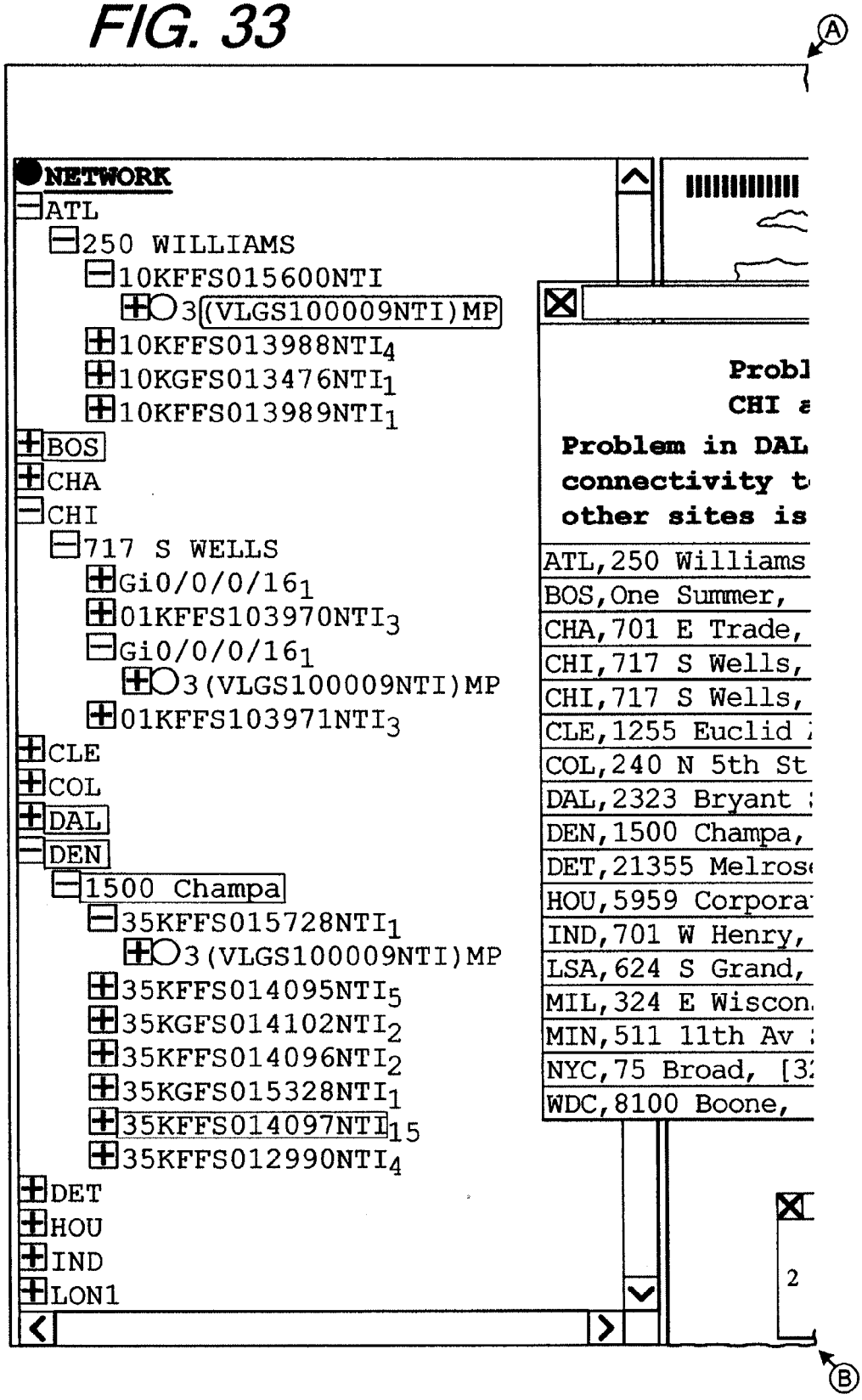

A
NETWORK
ATL
250 WILLIAMS
10KFFS015600NTI
3(VLGS100009NTI)MP
10KFFS013988NTI4
10KGFS013476NTI1
10KFFS013989NTI1
BOS
CHA
CHI
717 S WELLS
Gi0/0/0/161
01KFFS103970NTI3
Gi0/0/0/161
3(VLGS100009NTI)MP
01KFFS103971NTI3
CLE
COL
DAL
DEN
1500 Champa
35KFFS015728NTI1
3(VLGS100009NTI)MP
35KFFS014095NTI5
35KGFS014102NTI2
35KFFS014096NTI2
35KGFS015328NTI1
35KFFS014097NTI15
35KFFS012990NTI4
DET
HOU
IND
LON1
Probl
CHI a
Problem in DAL
connectivity t
other sites is
ATL,250 Williams
BOS,One Summer,
CHA,701 E Trade,
CHI,717 S Wells,
CHI,717 S Wells,
CLE,1255 Euclid
COL,240 N 5th St
DAL,2323 Bryant
DEN,1500 Champa,
DET,21355 Melros
HOU,5959 Corpora
IND,701 W Henry,
LSA,624 S Grand,
MIL,324 E Wiscon
MIN,511 11th Av
NYC,75 Broad, [3
WDC,8100 Boone,
2
B

FIG. 33

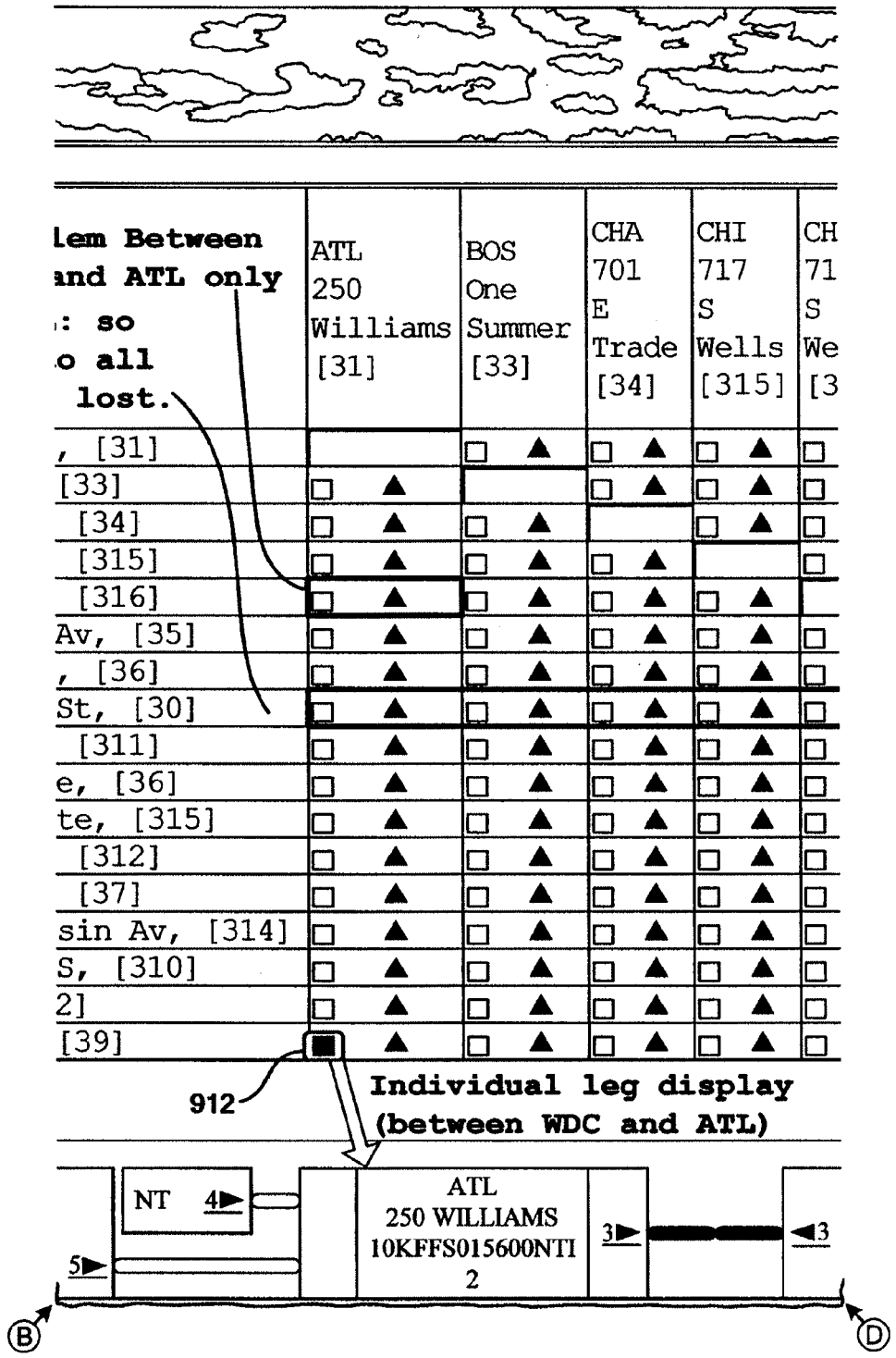

A
C
lem Between
and ATL only
: so
o all
lost.
ATL 250 Williams [31]
BOS One Summer [33]
CHA 701 E Trade [34]
CHI 717 S Wells [315]
CH 71 S We [3
, [31]
[33]
[34]
[315]
[316]
Av, [35]
, [36]
St, [30]
[311]
e, [36]
te, [315]
[312]
[37]
sin Av, [314]
S, [310]
2]
[39]
912
Individual leg display
(between WDC and ATL)
NT 4
5
ATL
250 WILLIAMS
10KFFS015600NTI
2
3
3
B
D

FIG. 33

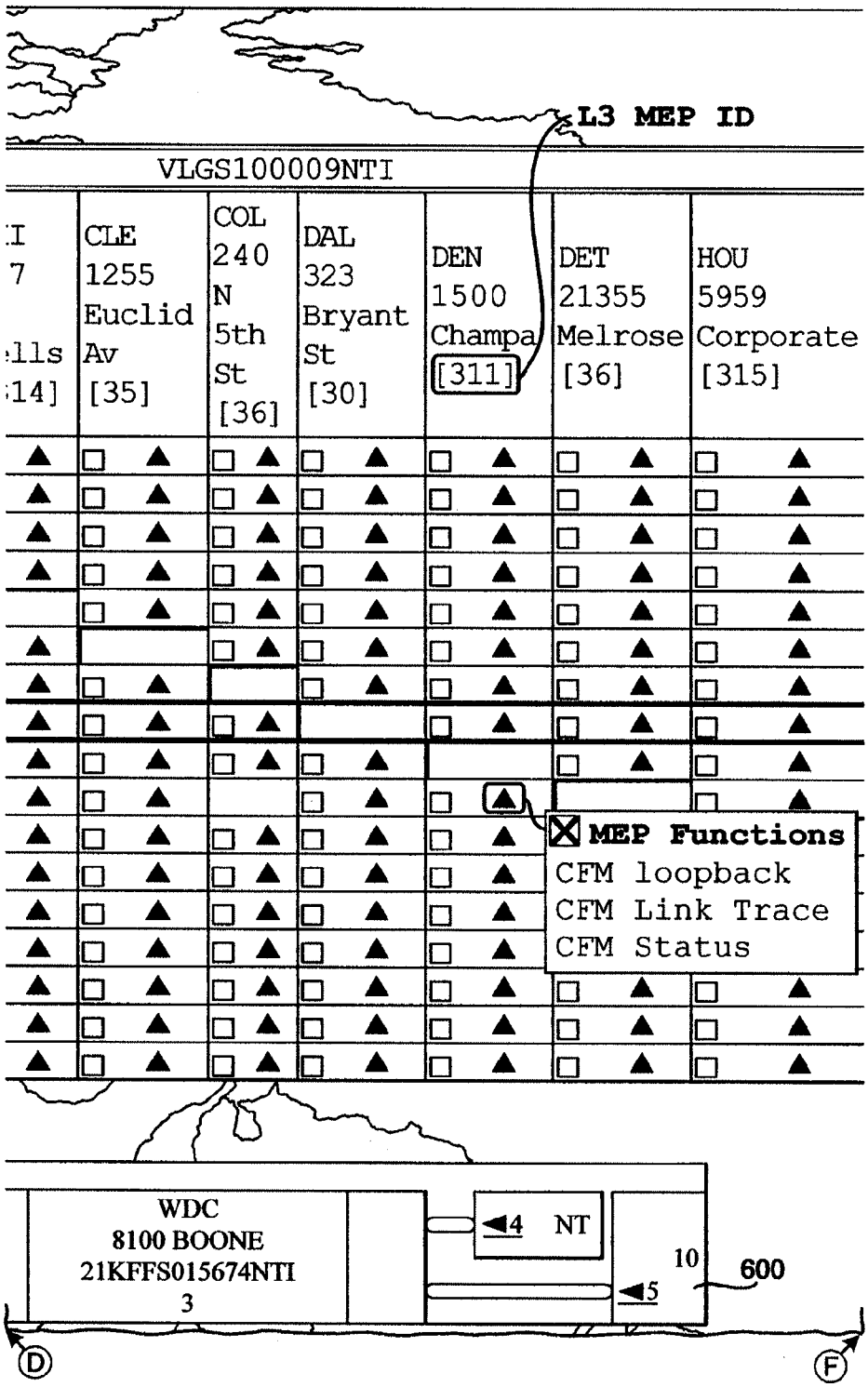

L3 MEP ID
VLGS100009NTI
CLE 1255 Euclid Av [35]
COL 240 N 5th St [36]
DAL 323 Bryant St [30]
DEN 1500 Champa [311]
DET 21355 Melrose [36]
HOU 5959 Corporate [315]
MEP Functions
CFM loopback
CFM Link Trace
CFM Status
WDC
8100 BOONE
21KFFS015674NTI
3
4 NT
5
10
600

FIG. 33

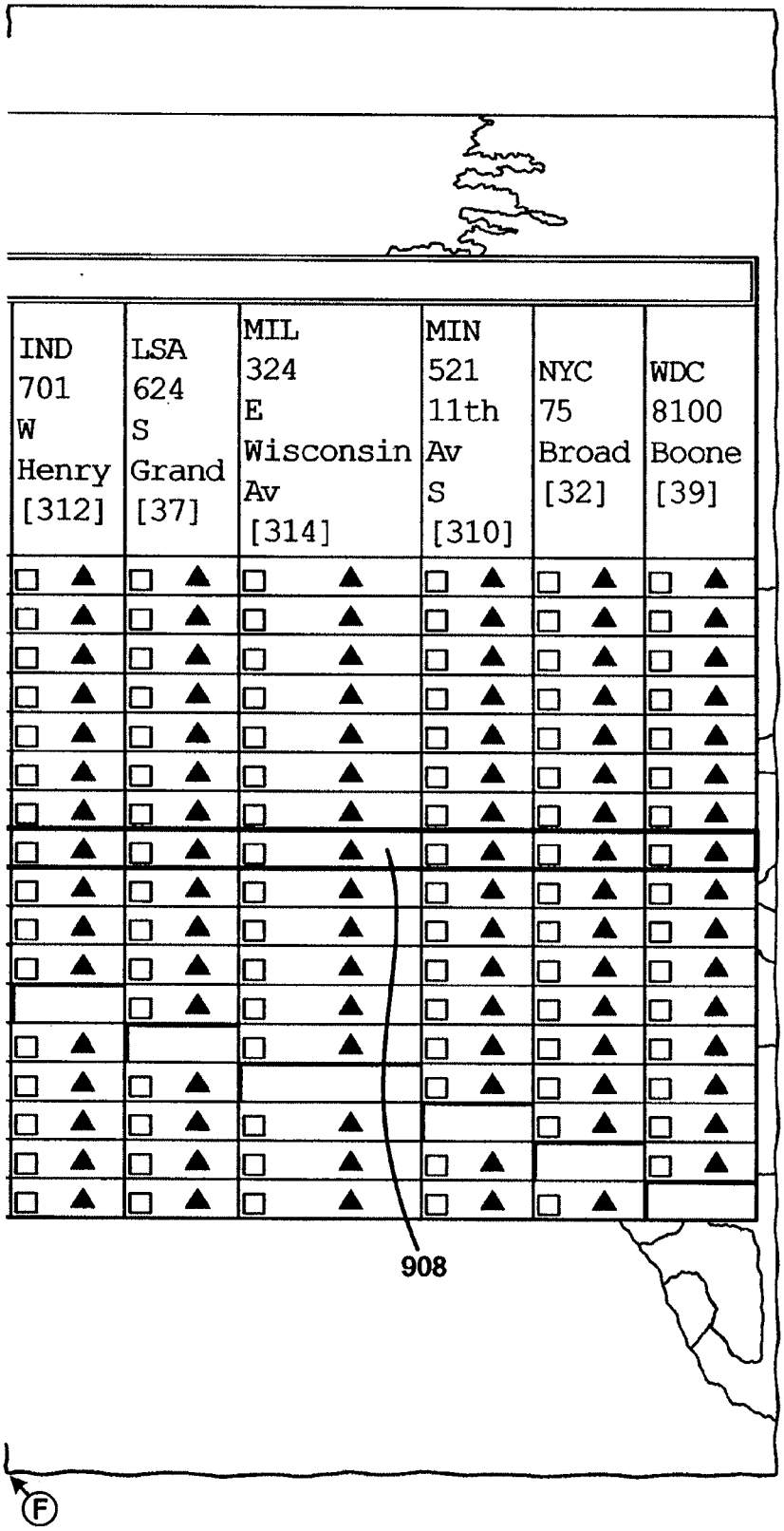

E
IND
701
W
Henry
[312]
LSA
624
S
Grand
[37]
MIL
324
E
Wisconsin
Av
[314]
MIN
521
11th
Av
S
[310]
NYC
75
Broad
[32]
WDC
8100
Boone
[39]
908
F

FIG. 34

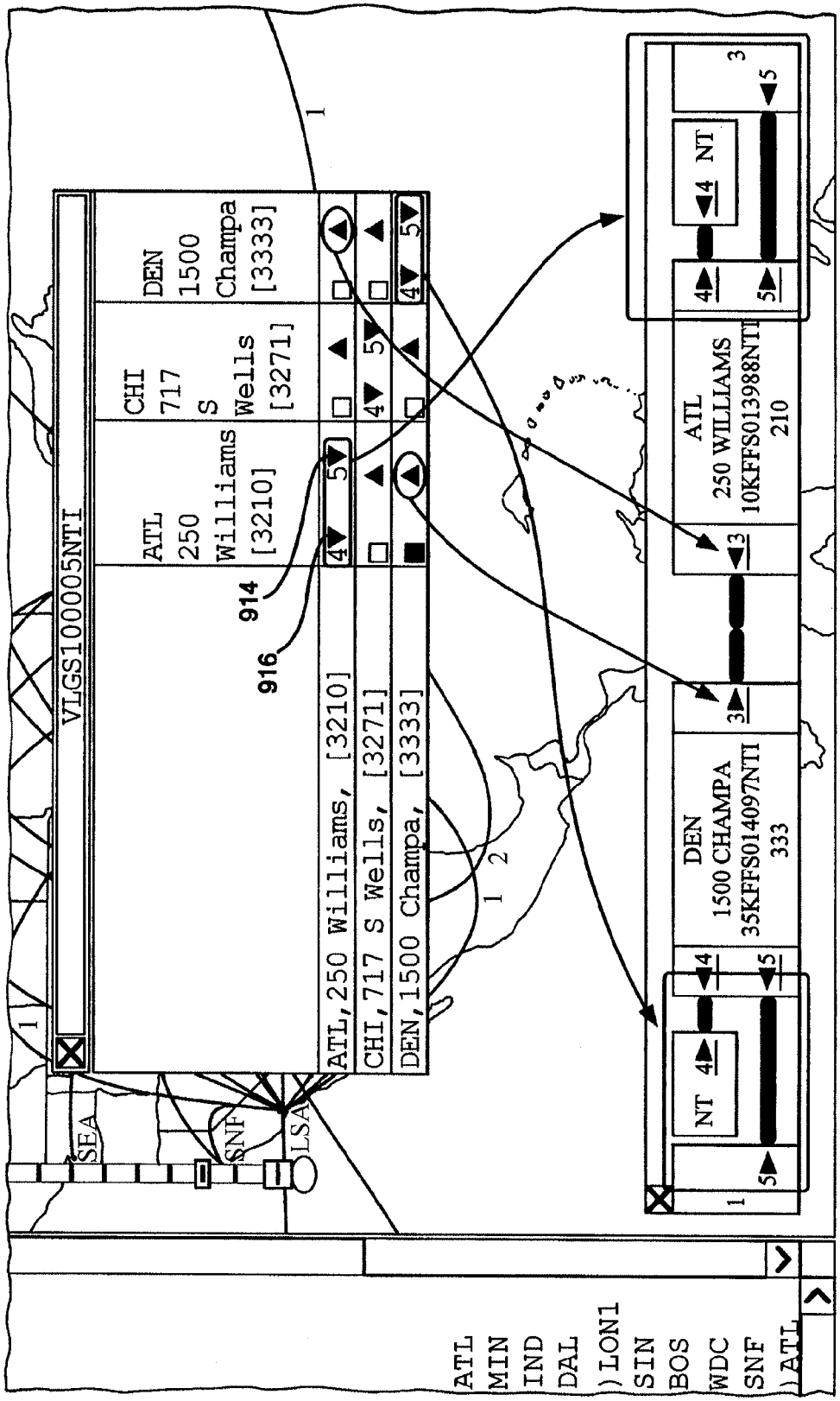

VLGS100005NTI
ATL 250 Williams [3210]
CHI 717 S Wells [3271]
DEN 1500 Champa [3333]
914
916
ATL,250 Williams, [3210]
CHI,717 S Wells, [3271]
DEN,1500 Champa, [3333]
SEA
SNF
LSA
ATL 250 WILLIAMS 10KFFS013988NTI 210
DEN 1500 CHAMPA 35KFFS014097NTI 333
NT
ATL
MIN
IND
DAL
) LON1
SIN
BOS
WDC
SNF
) ATL

FIG. 35

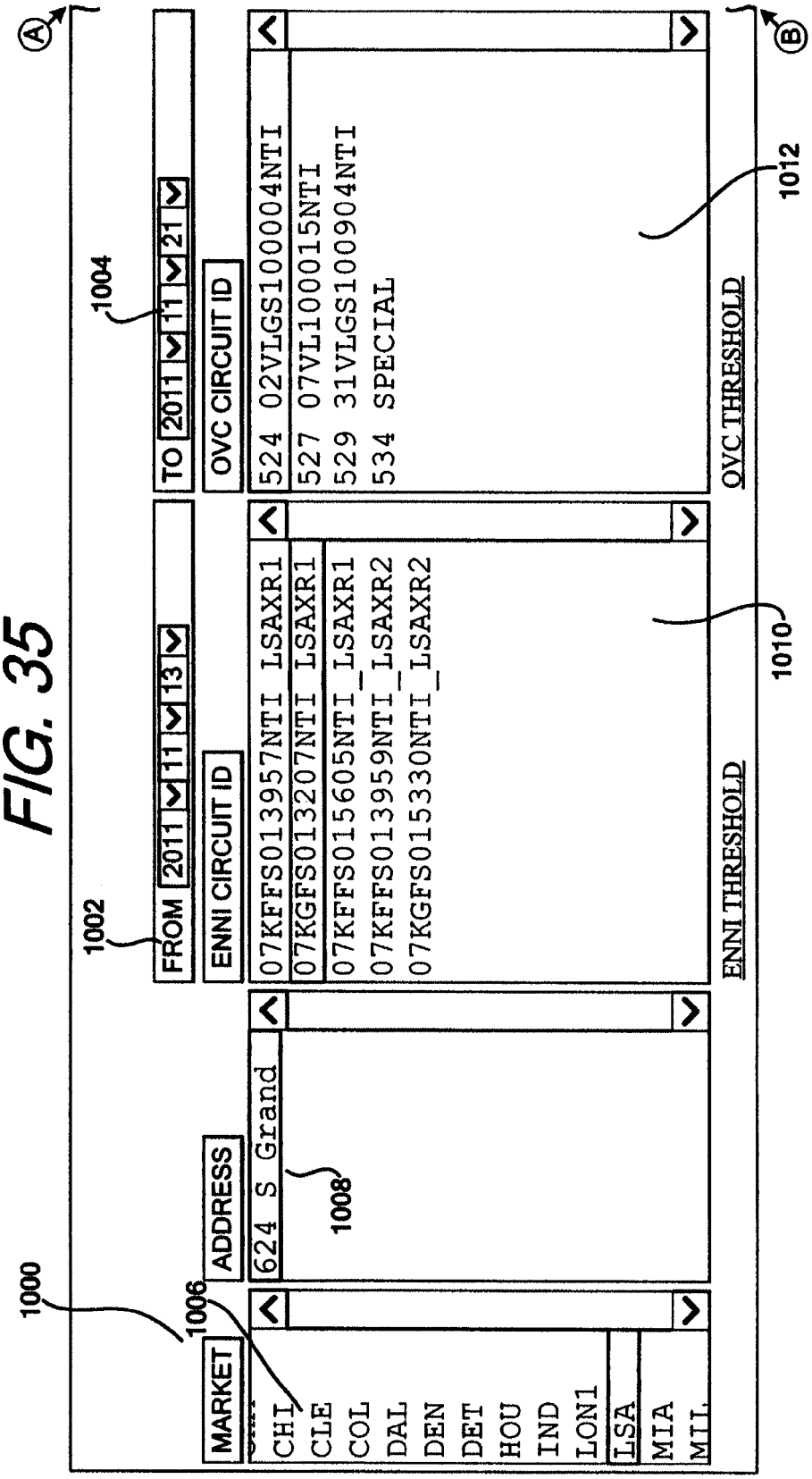

A
B
1000
1002
1004
1006
1008
1010
1012
MARKET
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
LSA
MIA
MIL
ADDRESS
624 S Grand
FROM 2011 11 13
ENNI CIRCUIT ID
07KFFS013957NTI LSAXR1
07KGFS013207NTI LSAXR1
07KFFS015605NTI_LSAXR1
07KFFS013959NTI_LSAXR2
07KGFS015330NTI_LSAXR2
ENNI THRESHOLD
TO 2011 11 21
OVC CIRCUIT ID
524 02VLGS100004NTI
527 07VL100015NTI
529 31VLGS100904NTI
534 SPECIAL
OVC THRESHOLD

FIG. 35

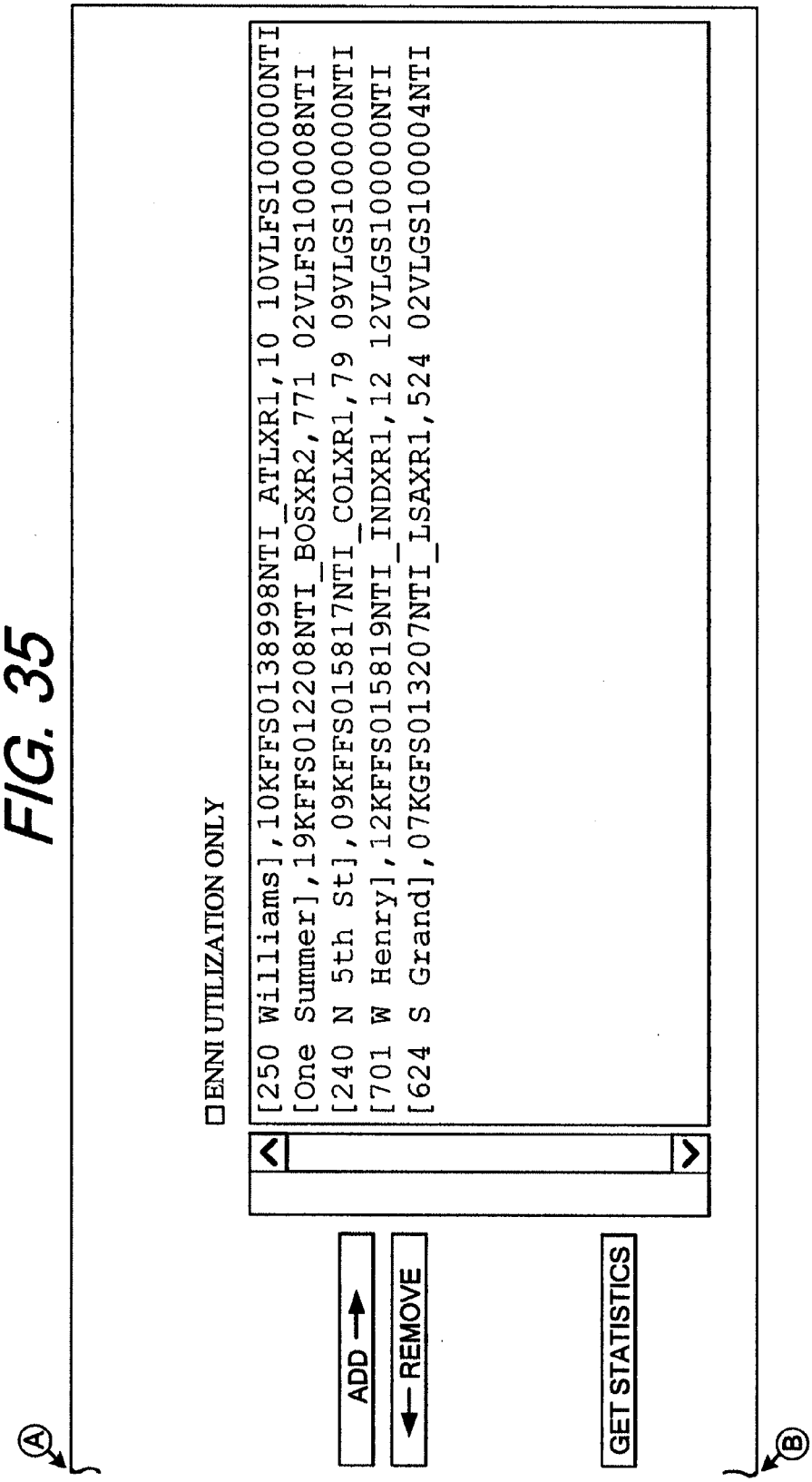

ENNI UTILIZATION ONLY
[250 Williams],10KFFS0138998NTI_ATLXR1,10 10VLFS100000NTI
[One Summer],19KFFS012208NTI_BOSXR2,771 02VLFS100008NTI
[240 N 5th St],09KFFS015817NTI_COLXR1,79 09VLGS100000NTI
[701 W Henry],12KFFS015819NTI_INDXR1,12 12VLGS100000NTI
[624 S Grand],07KGFS013207NTI_LSAXR1,524 02VLGS100004NTI
ADD
REMOVE
GET STATISTICS
A
B

FIG. 36

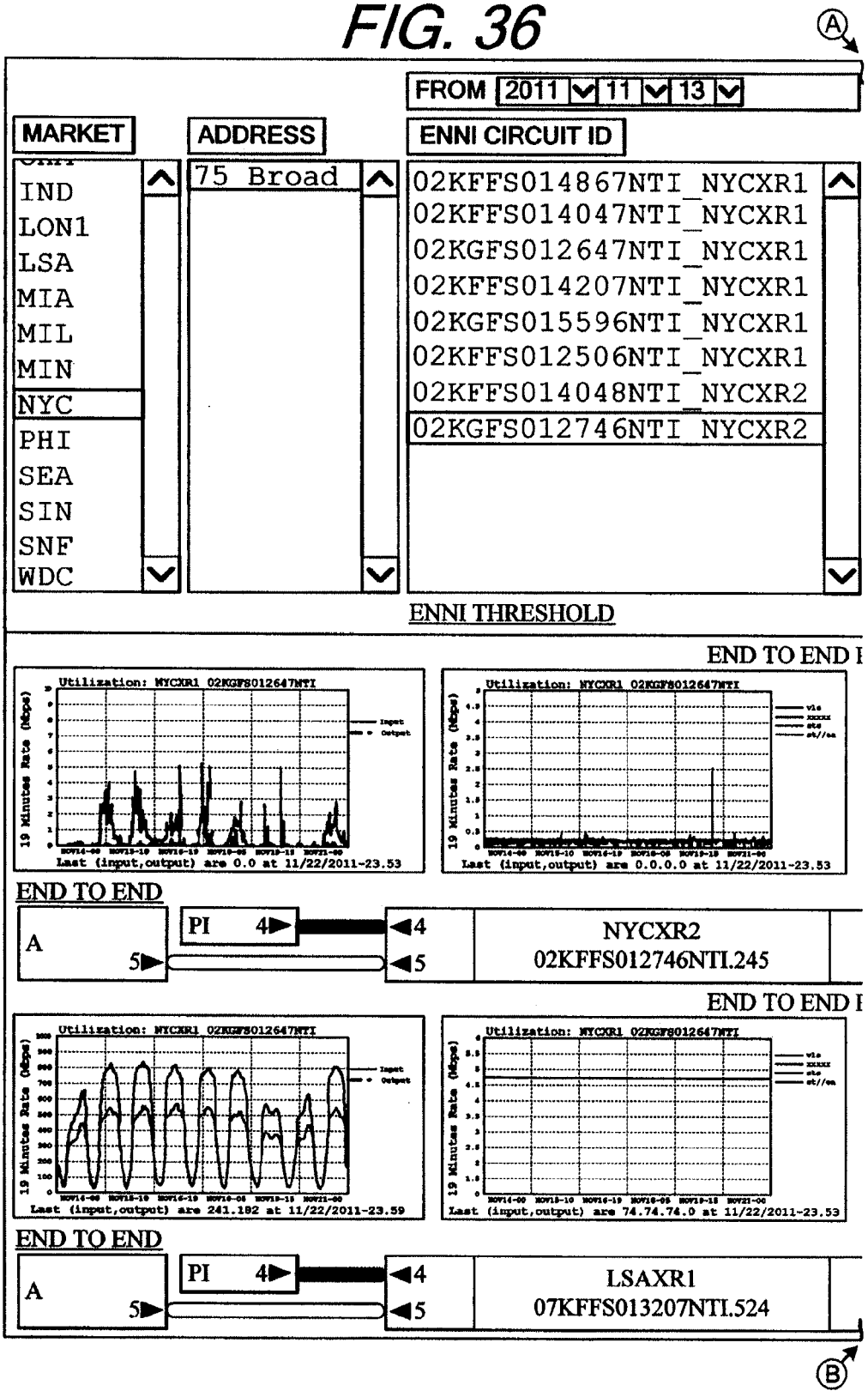

A
FROM 2011 11 13
MARKET
ADDRESS
ENNI CIRCUIT ID
IND
LON1
LSA
MIA
MIL
MIN
NYC
PHI
SEA
SIN
SNF
WDC
75 Broad
02KFFS014867NTI_NYCXR1
02KFFS014047NTI_NYCXR1
02KGFS012647NTI_NYCXR1
02KFFS014207NTI_NYCXR1
02KGFS015596NTI_NYCXR1
02KFFS012506NTI_NYCXR1
02KFFS014048NTI_NYCXR2
02KGFS012746NTI_NYCXR2
ENNI THRESHOLD
END TO END I
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Last (input,output) are 0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
END TO END
A
PI 4
5
4
5
NYCXR2
02KFFS012746NTI.245
END TO END I
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Last (input,output) are 241.192 at 11/22/2011-23.59
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 74.74.74.0 at 11/22/2011-23.53
END TO END
A
PI 4
5
4
5
LSAXR1
07KFFS013207NTI.524
B

FIG. 36

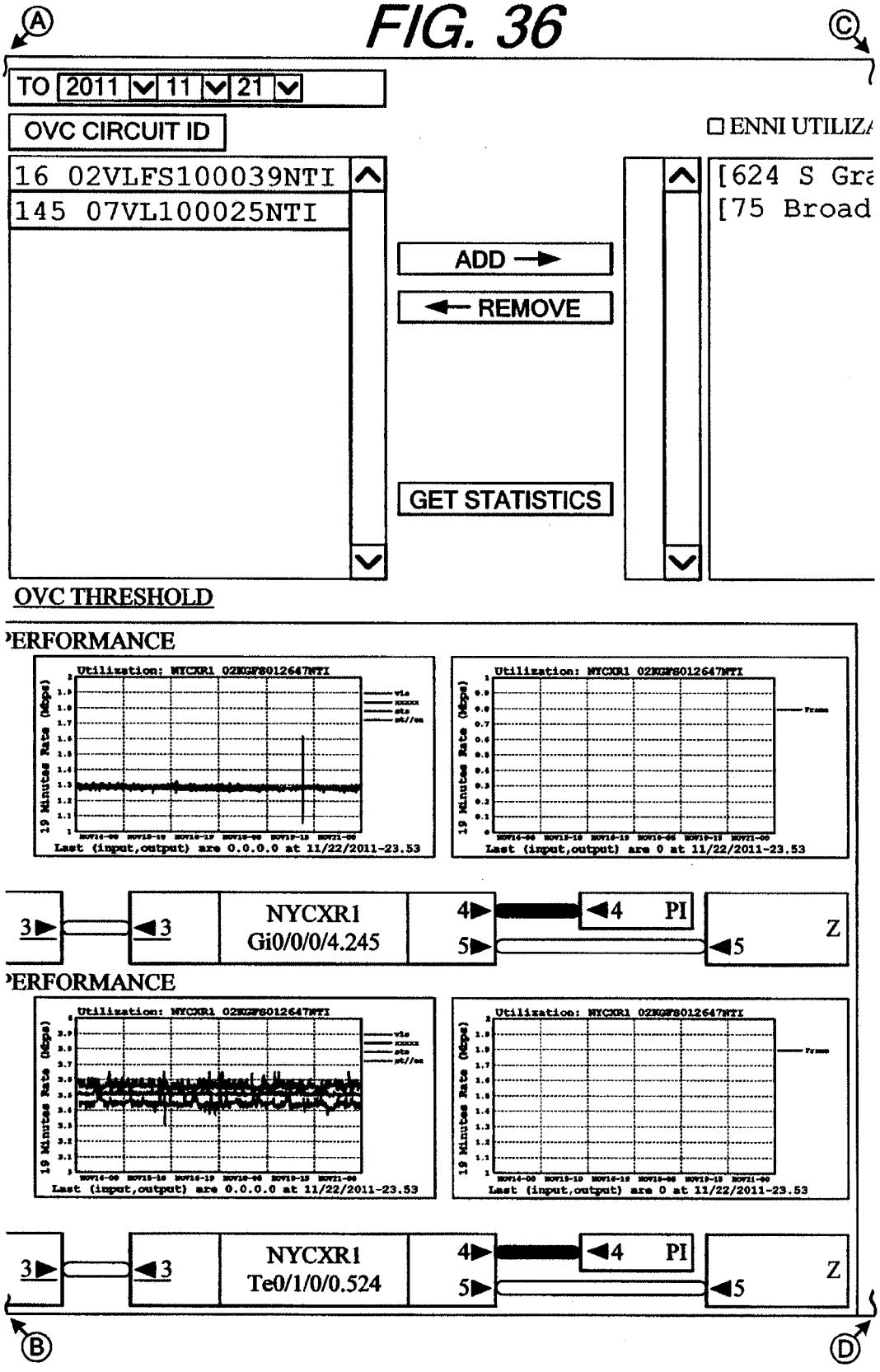

A
C
TO 2011 11 21
OVC CIRCUIT ID
ENNI UTILIZ
16 02VLFS100039NTI
145 07VL100025NTI
[624 S Gra
[75 Broad
ADD
REMOVE
GET STATISTICS
OVC THRESHOLD
ERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 0 at 11/22/2011-23.53
3
3
NYCXR1
Gi0/0/0/4.245
4
5
4
PI
5
Z
ERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Last (input,output) are 0 at 11/22/2011-23.53
3
3
NYCXR1
Te0/1/0/0.524
4
5
4
PI
5
Z
B
D

FIG. 36

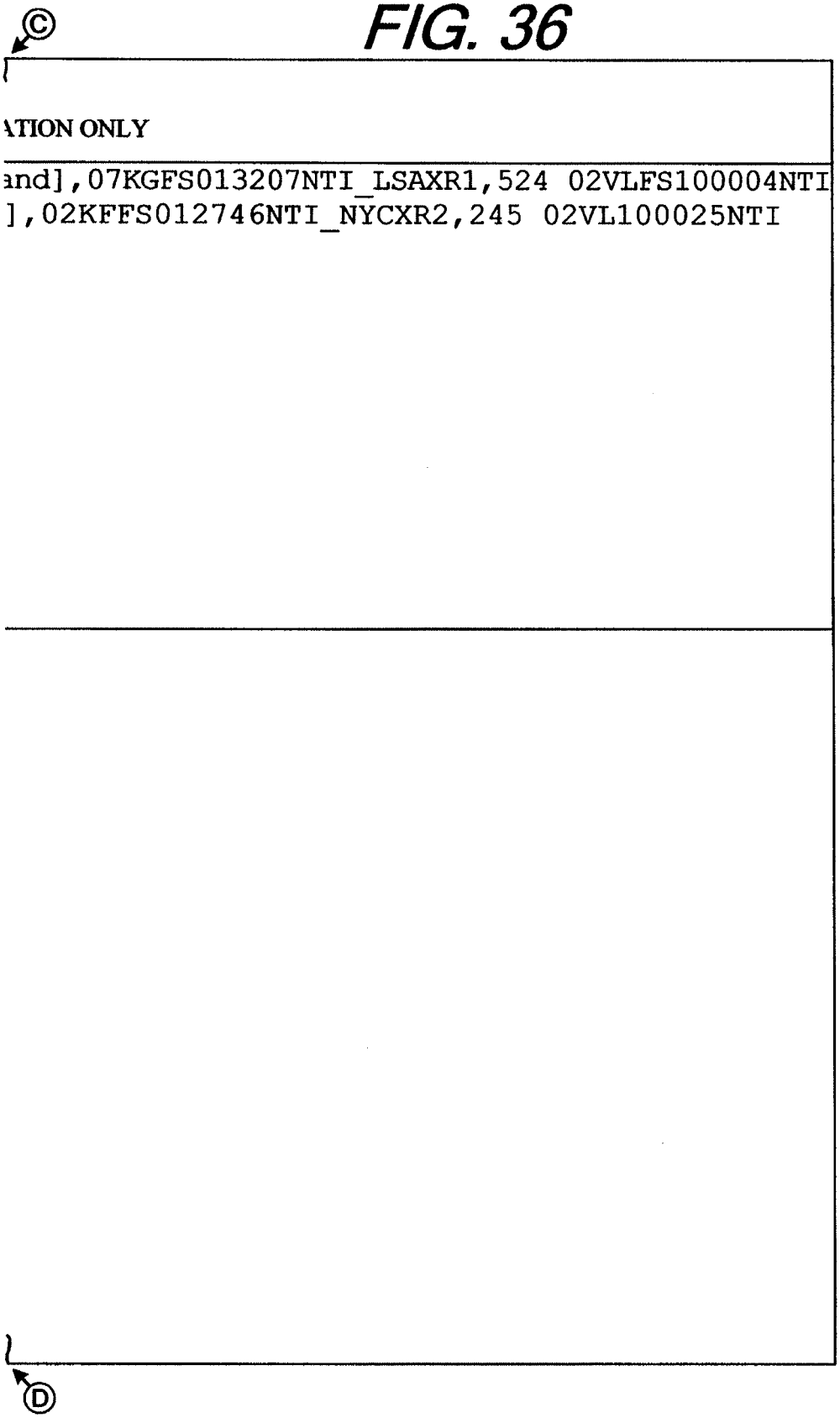

©
ATION ONLY
and],07KGFS013207NTI_LSAXR1,524 02VLFS100004NTI
],02KFFS012746NTI_NYCXR2,245 02VL100025NTI
D

FIG. 37

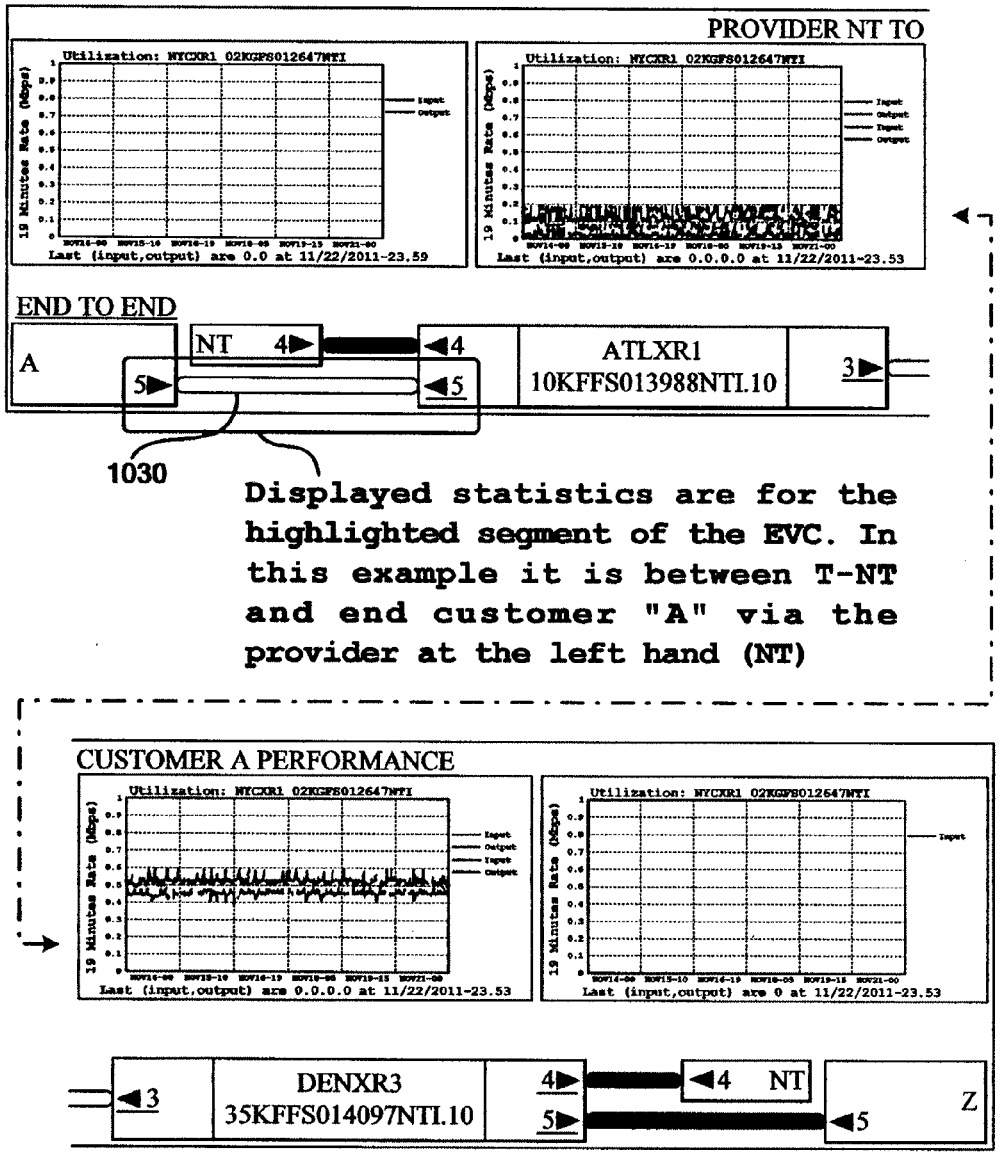

PROVIDER NT TO
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Last (input,output) are 0.0 at 11/22/2011-23.59
Utilization: NYCXR1 02KGFS012647NTI
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
END TO END
A
NT
4
5
4
5
ATLXR1
10KFFS013988NTI.10
3
1030
Displayed statistics are for the highlighted segment of the EVC. In this example it is between T-NT and end customer "A" via the provider at the left hand (NT)
CUSTOMER A PERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
Last (input,output) are 0 at 11/22/2011-23.53
3
DENXR3
35KFFS014097NTI.10
4
5
4
NT
5
Z

FIG. 38

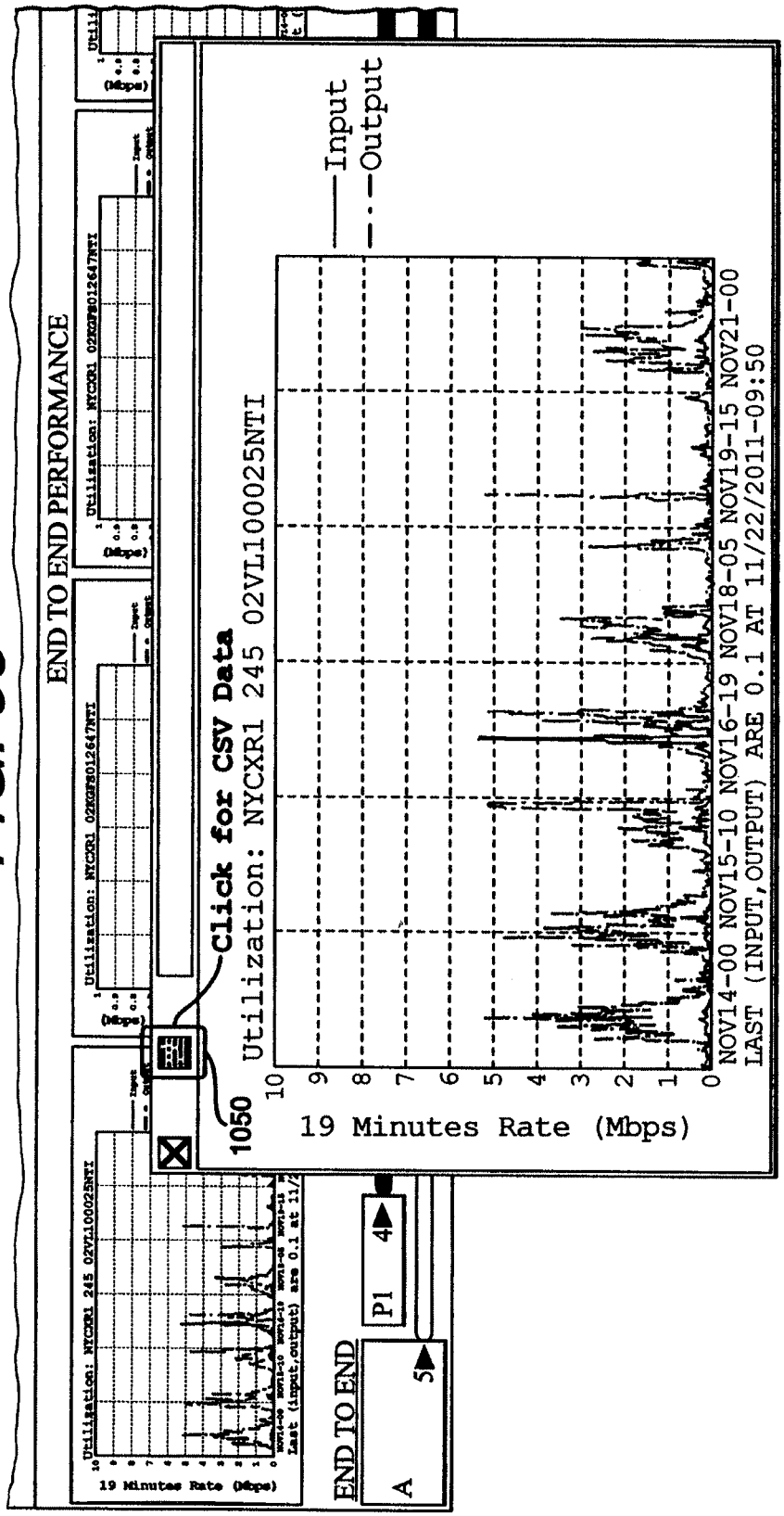

END TO END PERFORMANCE
Click for CSV Data
1050
Utilization: NYCXR1 245 02VL100025NTI
Input
Output
19 Minutes Rate (Mbps)
NOV14-00 NOV15-10 NOV16-19 NOV18-05 NOV19-15 NOV21-00
LAST (INPUT,OUTPUT) ARE 0.1 AT 11/22/2011-09:50
END TO END
A
5
P1
4

FIG. 39

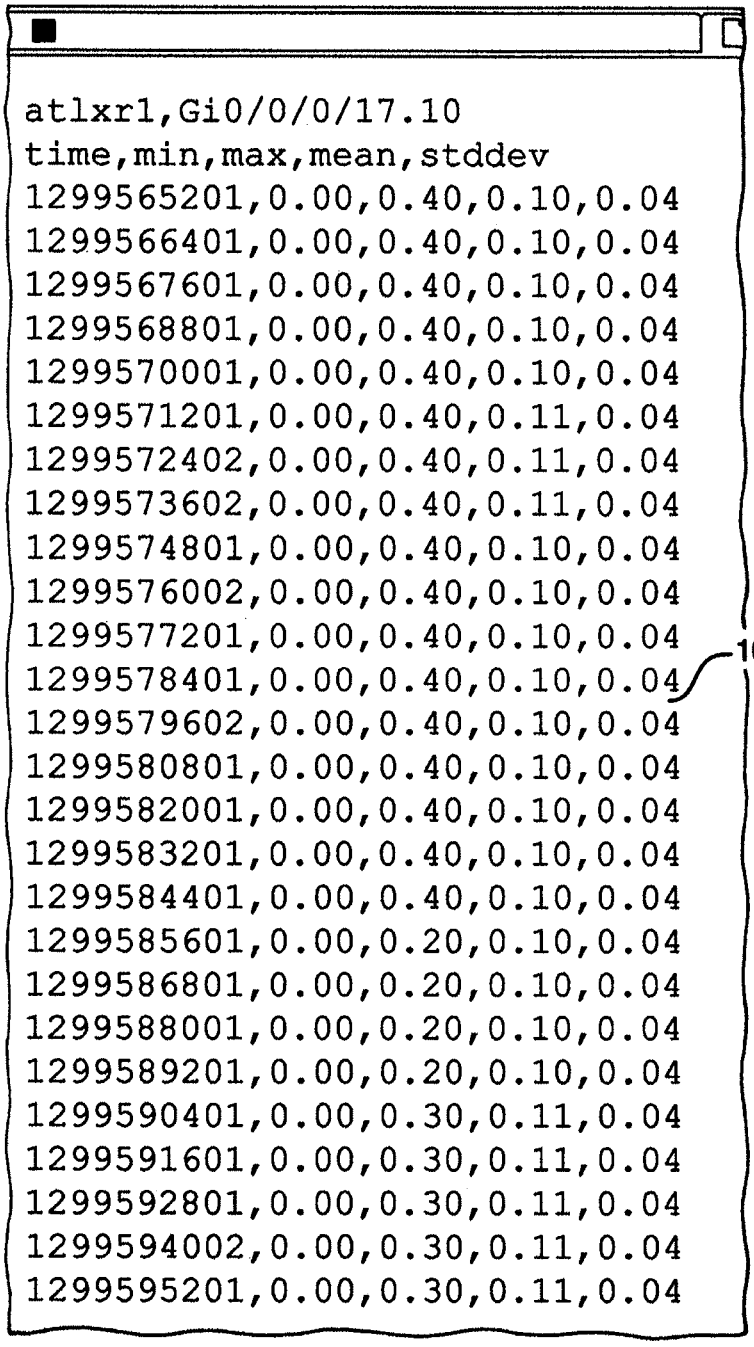

atlxr1,Gi0/0/0/17.10
time,min,max,mean,stddev
1299565201,0.00,0.40,0.10,0.04
1299566401,0.00,0.40,0.10,0.04
1299567601,0.00,0.40,0.10,0.04
1299568801,0.00,0.40,0.10,0.04
1299570001,0.00,0.40,0.10,0.04
1299571201,0.00,0.40,0.11,0.04
1299572402,0.00,0.40,0.11,0.04
1299573602,0.00,0.40,0.11,0.04
1299574801,0.00,0.40,0.10,0.04
1299576002,0.00,0.40,0.10,0.04
1299577201,0.00,0.40,0.10,0.04
1299578401,0.00,0.40,0.10,0.04
1299579602,0.00,0.40,0.10,0.04
1299580801,0.00,0.40,0.10,0.04
1299582001,0.00,0.40,0.10,0.04
1299583201,0.00,0.40,0.10,0.04
1299584401,0.00,0.40,0.10,0.04
1299585601,0.00,0.20,0.10,0.04
1299586801,0.00,0.20,0.10,0.04
1299588001,0.00,0.20,0.10,0.04
1299589201,0.00,0.20,0.10,0.04
1299590401,0.00,0.30,0.11,0.04
1299591601,0.00,0.30,0.11,0.04
1299592801,0.00,0.30,0.11,0.04
1299594002,0.00,0.30,0.11,0.04
1299595201,0.00,0.30,0.11,0.04
1052

FIG. 40

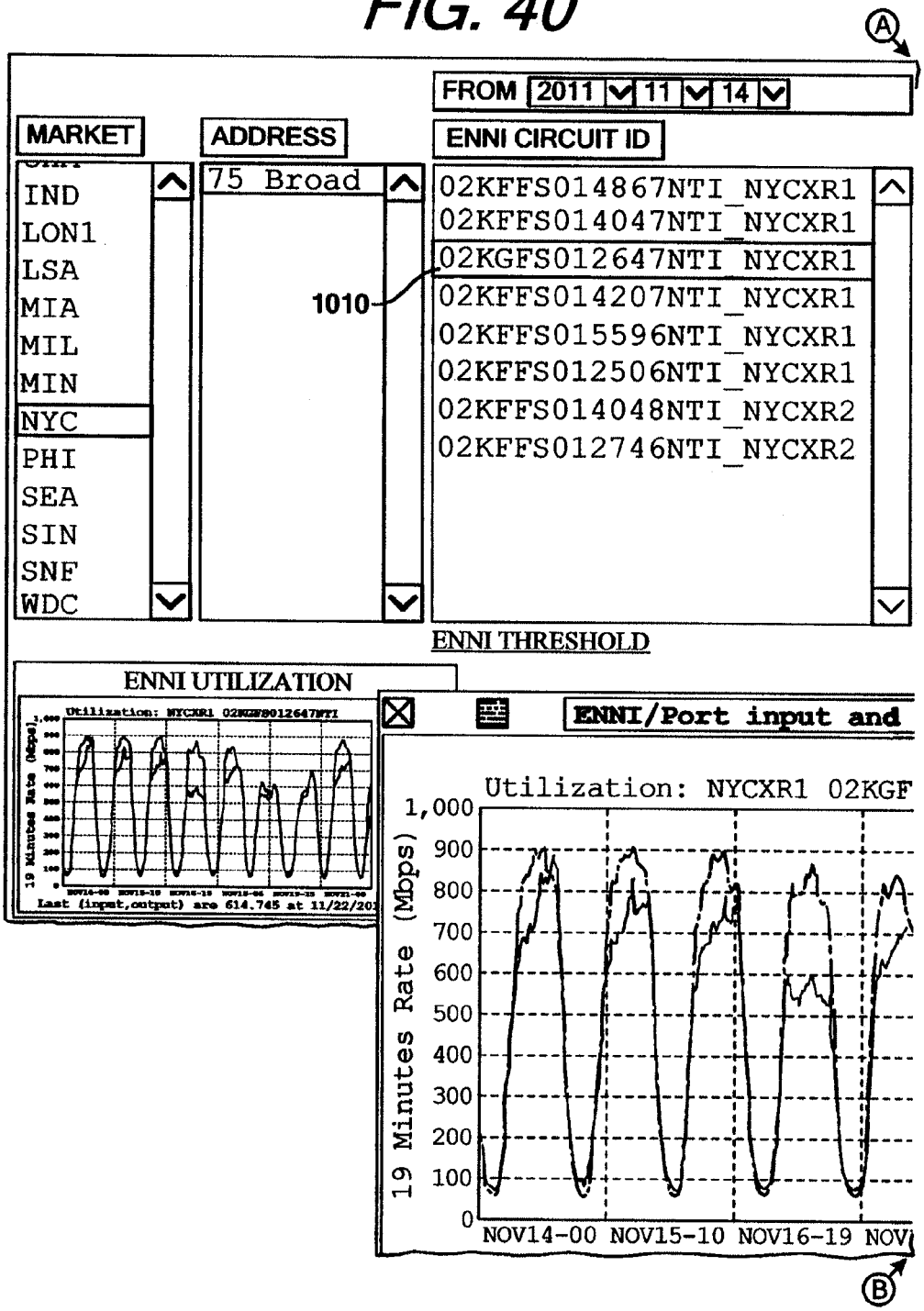

A
FROM 2011 11 14
MARKET
ADDRESS
ENNI CIRCUIT ID
IND
LON1
LSA
MIA
MIL
MIN
NYC
PHI
SEA
SIN
SNF
WDC
75 Broad
1010
02KFFS014867NTI_NYCXR1
02KFFS014047NTI_NYCXR1
02KGFS012647NTI_NYCXR1
02KFFS014207NTI_NYCXR1
02KFFS015596NTI_NYCXR1
02KFFS012506NTI_NYCXR1
02KFFS014048NTI_NYCXR2
02KFFS012746NTI_NYCXR2
ENNI THRESHOLD
ENNI UTILIZATION
ENNI/Port input and
Utilization: NYCXR1 02KGF
19 Minutes Rate (Mbps)
1,000
900
800
700
600
500
400
300
200
100
0
NOV14-00 NOV15-10 NOV16-19 NOV
B

FIG. 40

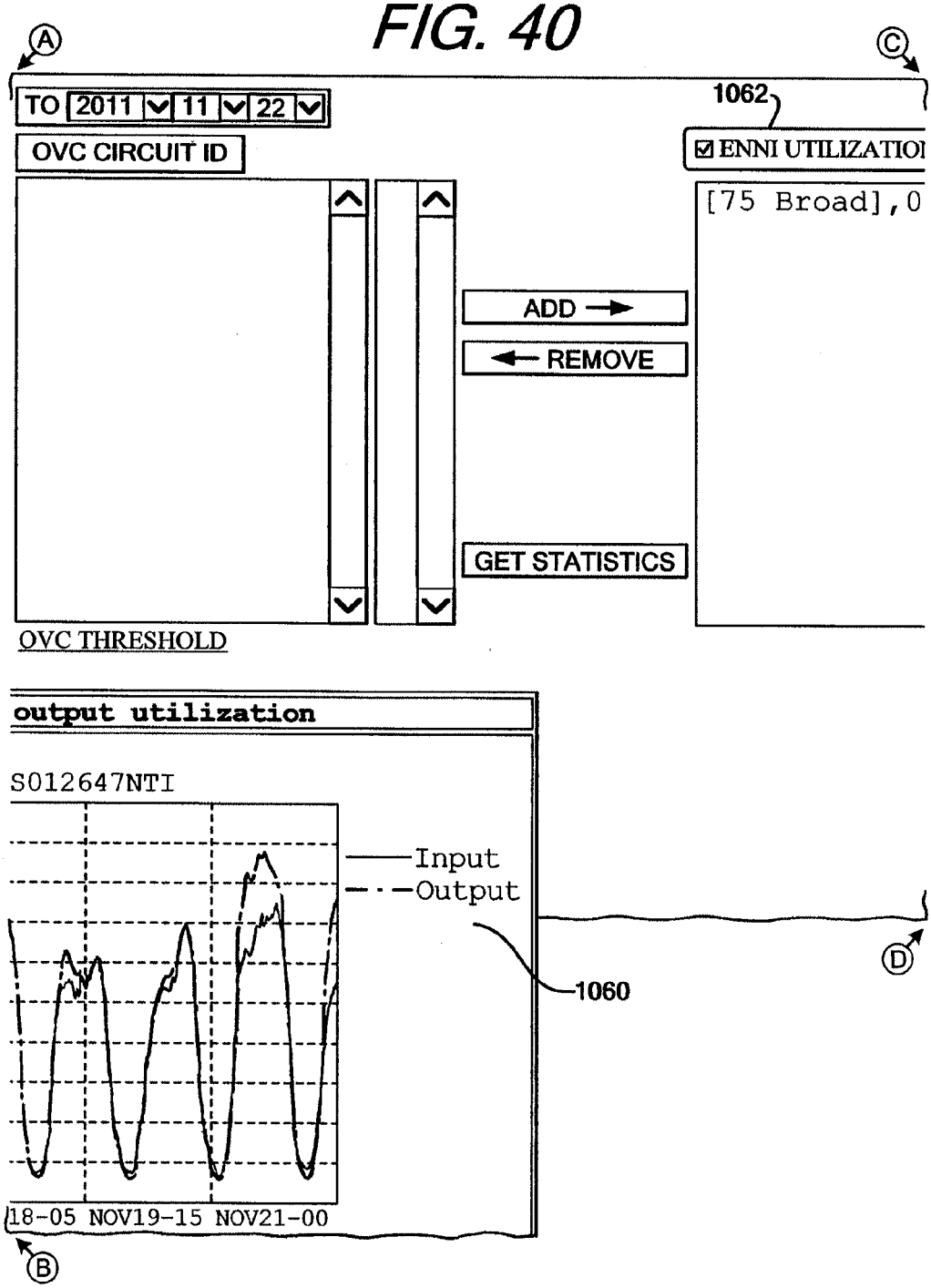

A
C
TO 2011 11 22
1062
OVC CIRCUIT ID
ENNI UTILIZATIOI
[75 Broad],0
ADD
REMOVE
GET STATISTICS
OVC THRESHOLD
output utilization
S012647NTI
Input
Output
1060
D
18-05 NOV19-15 NOV21-00
B

FIG. 40

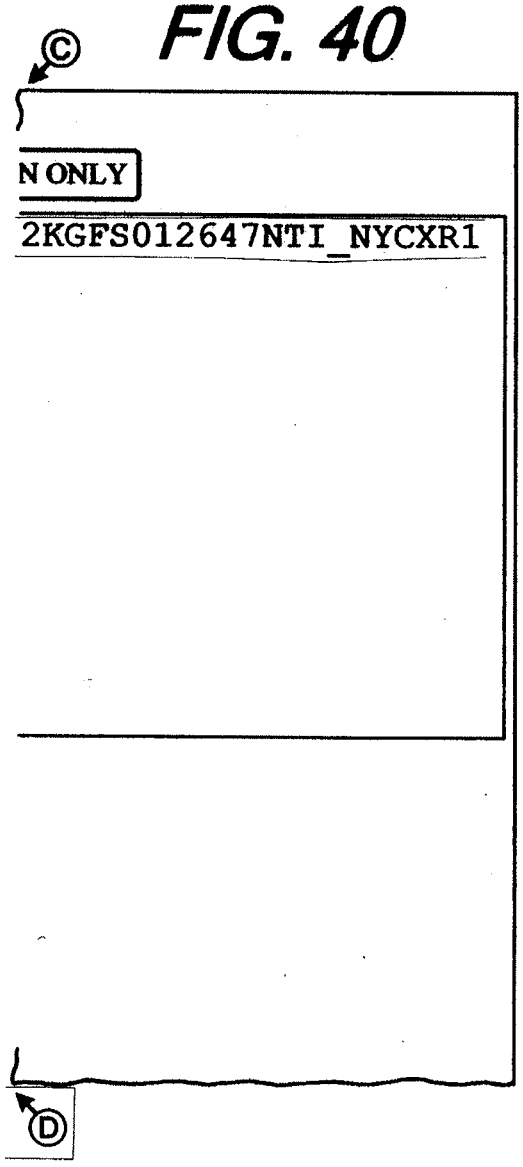


FIG. 41

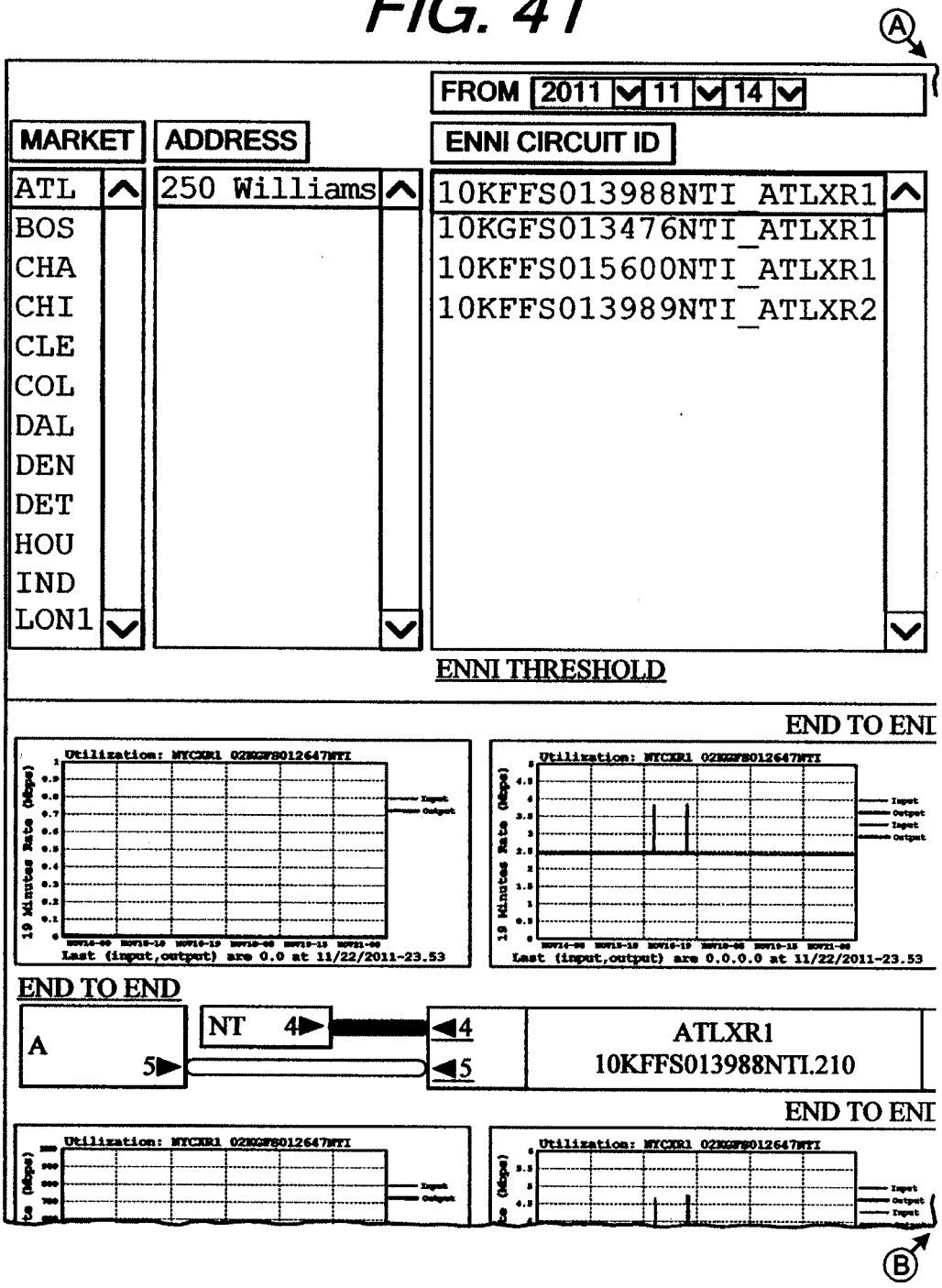

A
FROM 2011 11 14
MARKET
ADDRESS
ENNI CIRCUIT ID
ATL
BOS
CHA
CHI
CLE
COL
DAL
DEN
DET
HOU
IND
LON1
250 Williams
10KFFS013988NTI_ATLXR1
10KGFS013476NTI_ATLXR1
10KFFS015600NTI_ATLXR1
10KFFS013989NTI_ATLXR2
ENNI THRESHOLD
END TO ENI
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Last (input,output) are 0.0 at 11/22/2011-23.53
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
END TO END
A
NT 4
5
4
5
ATLXR1
10KFFS013988NTI.210
END TO ENI
B

FIG. 41

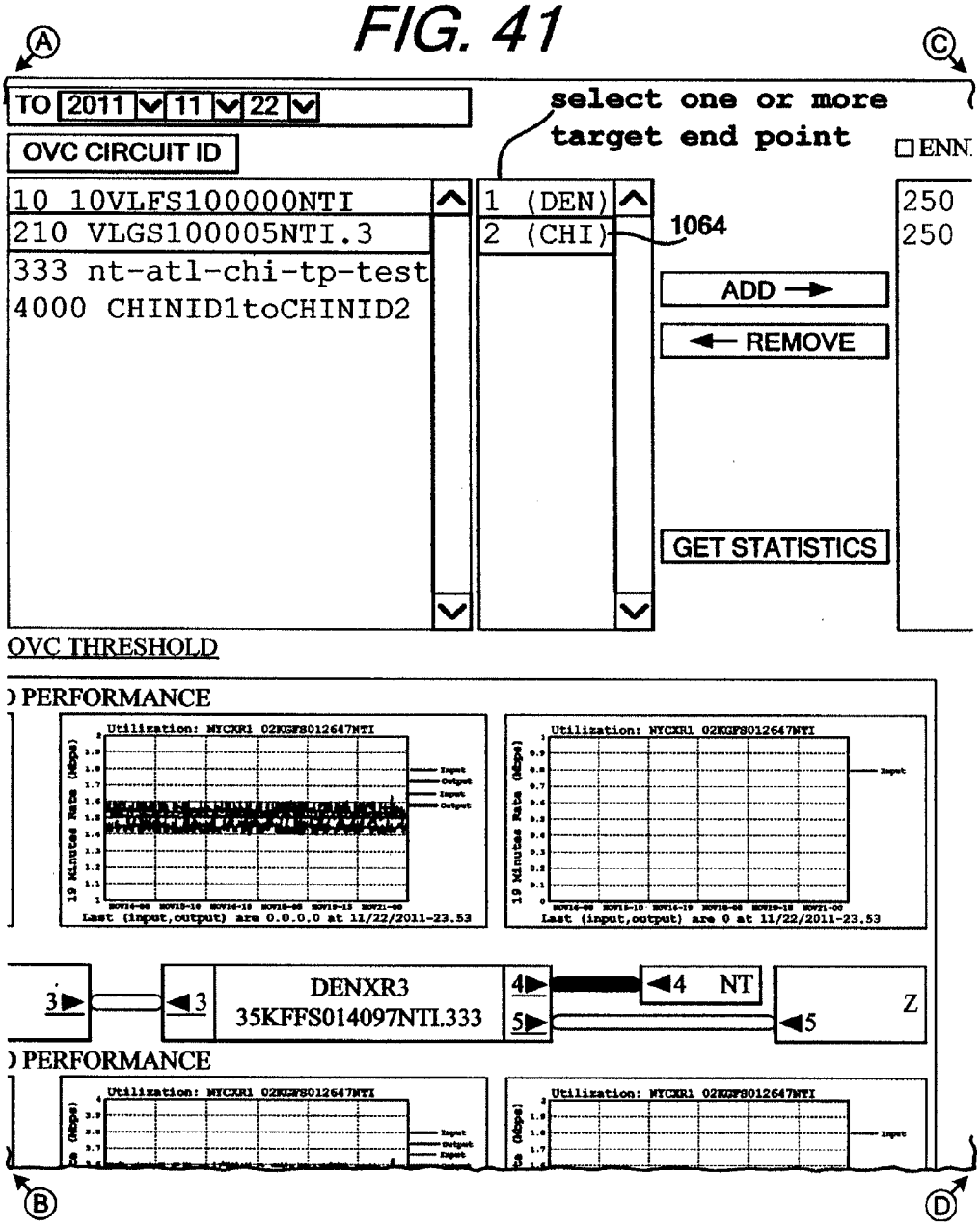

A
C
TO 2011 11 22
select one or more target end point
OVC CIRCUIT ID
ENN.
10 10VLFS100000NTI
210 VLGS100005NTI.3
333 nt-atl-chi-tp-test
4000 CHINID1toCHINID2
1 (DEN)
2 (CHI)
1064
250
250
ADD
REMOVE
GET STATISTICS
OVC THRESHOLD
PERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
Last (input,output) are 0 at 11/22/2011-23.53
3
3
DENXR3
35KFFS014097NTI.333
4
5
4 NT
5
Z
PERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
Utilization: NYCXR1 02KGFS012647NTI
B
D

FIG. 41

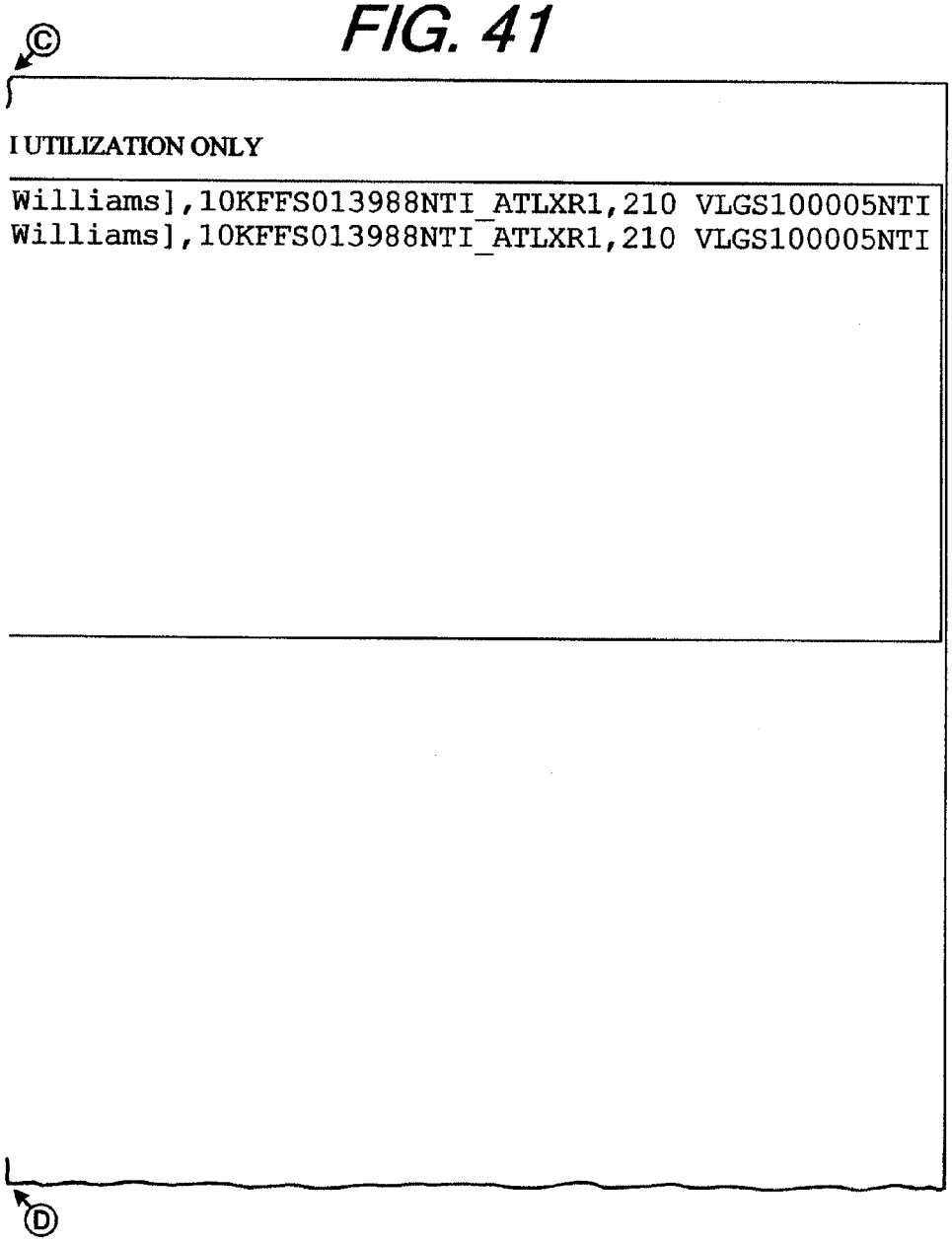

©
I UTILIZATION ONLY
Williams],10KFFS013988NTI_ATLXR1,210 VLGS100005NTI
Williams],10KFFS013988NTI_ATLXR1,210 VLGS100005NTI
D

FIG. 42

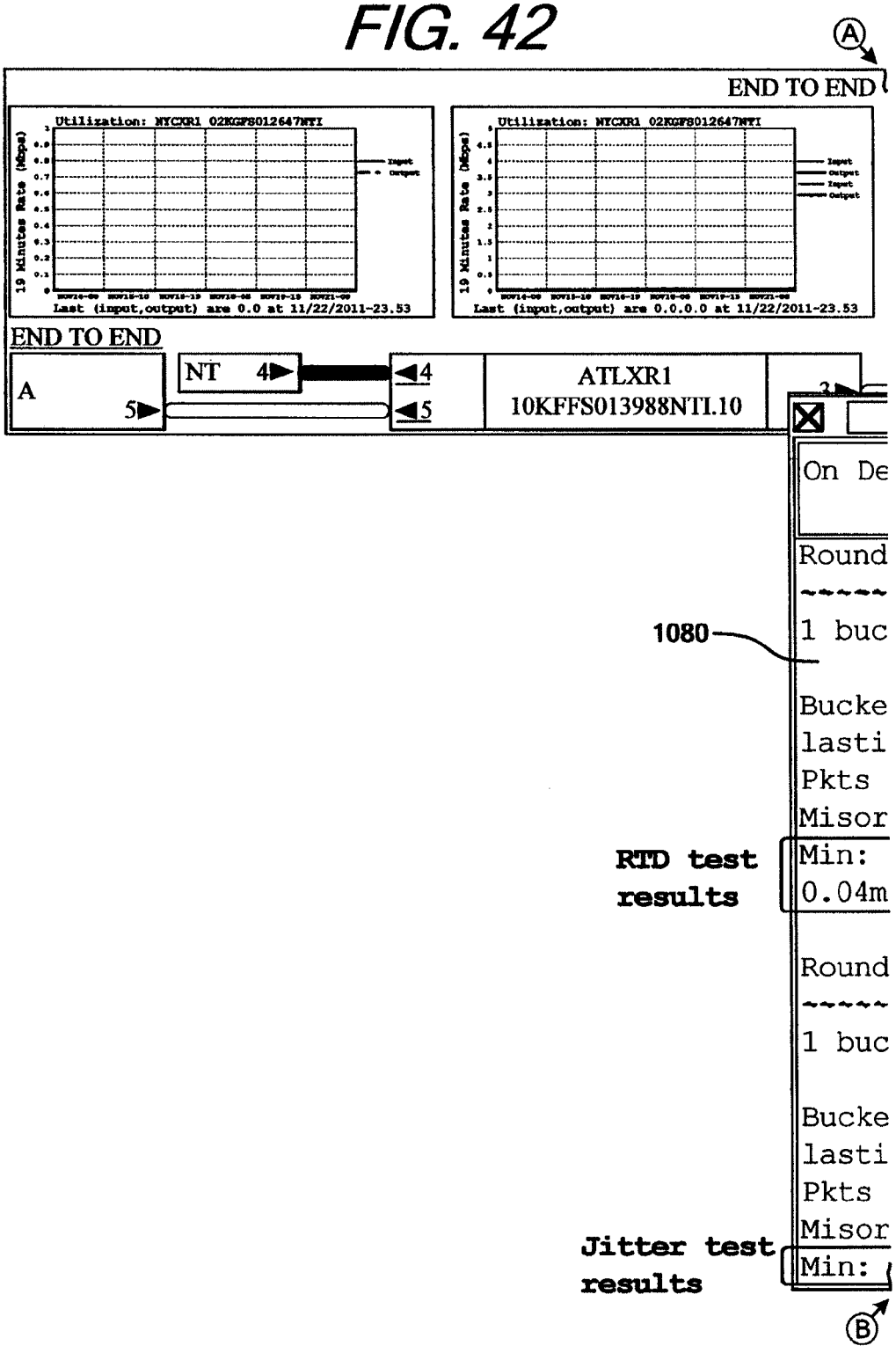
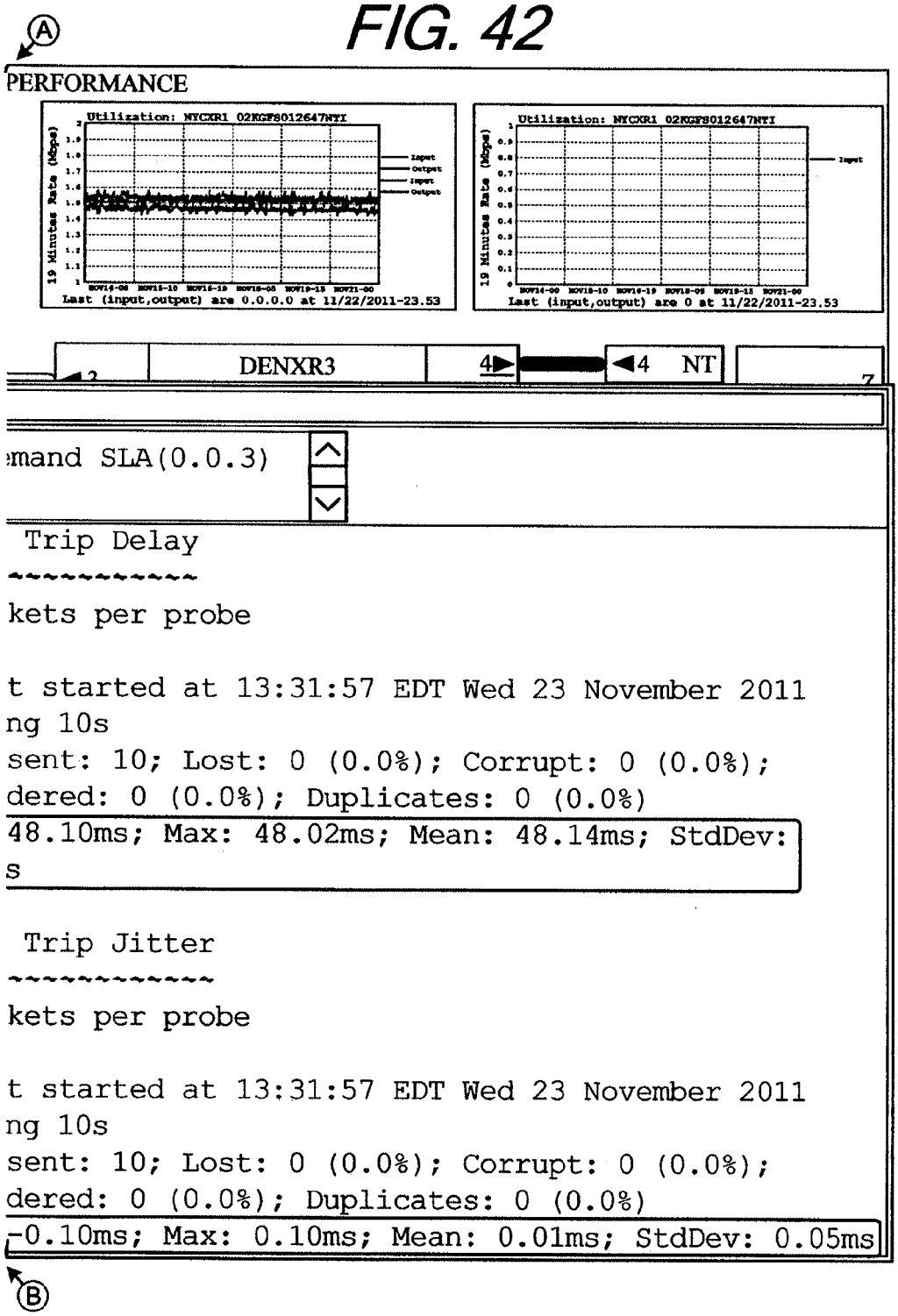

A
END TO END
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Last (input,output) are 0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Input
Output
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
END TO END
A
5
NT 4
4
5
ATLXR1
10KFFS013988NTI.10
On De
Round
1 buc
1080
Bucke
lasti
Pkts
Misor
RTD test results
Min:
0.04m
Round
1 buc
Bucke
lasti
Pkts
Misor
Jitter test results
Min:
B

FIG. 42


A
PERFORMANCE
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Output
Input
Output
Last (input,output) are 0.0.0.0 at 11/22/2011-23.53
Utilization: NYCXR1 02KGFS012647NTI
19 Minutes Rate (Mbps)
Input
Last (input,output) are 0 at 11/22/2011-23.53
DENXR3
4
4 NT
mand SLA(0.0.3)
Trip Delay
kets per probe
t started at 13:31:57 EDT Wed 23 November 2011
ng 10s
sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
dered: 0 (0.0%); Duplicates: 0 (0.0%)
48.10ms; Max: 48.02ms; Mean: 48.14ms; StdDev:
s
Trip Jitter
kets per probe
t started at 13:31:57 EDT Wed 23 November 2011
ng 10s
sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
dered: 0 (0.0%); Duplicates: 0 (0.0%)
-0.10ms; Max: 0.10ms; Mean: 0.01ms; StdDev: 0.05ms
B

SYSTEMS AND METHODS FOR DIAGNOSTIC, PERFORMANCE AND FAULT MANAGEMENT OF A NETWORK

PRIORITY CLAIM

[0001] This is a non-provisional application claiming priority to, and the benefit of, U.S. Provisional Patent Application No. 61/606,229, filed on Mar. 2, 2012, the entire contents of which is incorporated by reference herein.

TECHNICAL FIELD

[0002] This disclosure relates to the field of telecommunications, and more particularly to diagnostics, performance and fault management of a network comprised of multiple networks, such as a central network and multiple provider networks, which may comprise, for example, one or more Ethernet networks.

BACKGROUND

[0003] The fact that networks connect multiple systems through multiple interfaces results in a plurality of locations on any given network where a fault or performance impairment may occur. Such analysis, fault and performance management is further complicated when an overall network is comprised of a central network and multiple separately owned provider networks. The systems and methods described herein involve but are not limited to providing network analysis, real time fault and performance management information to analyze, monitor, detect and address such issues.

SUMMARY

[0004] A system for analyzing, monitoring and detecting fault and performance across a network comprised of one or more networks of external elements is provided. The system permits users to monitor the connectivity status of the different links of the network. In another aspect of the system, event and system performance information is provided to a user, The system also permits users to isolate certain portions of the network and review system performance data and events related to those isolated portions of the network. The system permits such fault management across multiple connected networks, portions of which may be owned or administered by different parties. These and other aspects will become readily apparent from the written specification, drawings, and claims provided herein.

BRIEF DESCRIPTION OF DRAWINGS

[0005] FIG. **1** is a schematic diagram illustrating an exemplary embodiment of a system in accordance with one or more aspects described herein.

[0006] FIG. **2** is a schematic diagram illustrating the connectivity of an exemplary embodiment of a system in accordance with one or more aspects described herein.

[0007] FIGS. **3**A-**3**B are schematic diagrams illustrating exemplary edge location configurations according to one or more aspects described herein.

[0008] FIGS. **4**A-**4**B are schematic diagrams illustrating exemplary edge location configurations according to one or more aspects described herein.

[0009] FIG. **5** is a schematic diagram of an exemplary network configuration in connection with application services for purposes of illustrating one or more aspects described herein.

[0010] FIGS. **6-42** are exemplary illustrations of screenshots associated with an exemplary embodiment of a portal in accordance with on or more aspects described herein.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0011] The description that follows describes, illustrates and exemplifies one or more particular embodiments of the invention(s) in accordance with its principles. This description is not provided to limit the invention(s) to the embodiments described herein, but rather to explain and teach the principles of the invention(s) in such a way to enable one of ordinary skill in the art to understand these principles and, with that understanding, be able to apply them to practice not only the embodiments described herein, but also other embodiments that may come to mind in accordance with these principles. The scope of the invention(s) is/are intended to cover-all such embodiments that may fall within the scope of the claims, either literally or under the doctrine of equivalents.

[0012] It should be noted that in the description and drawings, like or substantially similar elements may be labeled with the same reference numerals. However, sometimes these elements may be labeled with differing numbers, such as, for example, in cases where such labeling facilitates a more clear description. Additionally, the drawings set forth herein are not necessarily drawn to scale, and in some instances proportions may have been exaggerated to more clearly depict certain features. Such labeling and drawing practices do not necessarily implicate an underlying substantive purpose. As stated above, the present specification is intended to be taken as a whole and interpreted in accordance with the principles of the invention(s) as taught herein and understood to one of ordinary skill in the art.

[0013] FIG. **1** is a schematic diagram illustrating an exemplary system framework **100** within which one or more principles of the invention(s) may be employed. At the outset, it should be understood that the invention may be embodied by, or employed in, numerous configurations and components, including one or more system, hardware, software, or firmware configurations or components, or any combination thereof, as understood by one of ordinary skill in the art. Furthermore, the invention(s) should not be construed as limited by the schematic illustrated in FIG. **1**, nor any of the exemplary embodiments described herein.

[0014] System **100** includes an overall network **102**, such as an Ethernet network. The overall network has a central network **115**, sometimes referred to herein as the backbone. The central network **115** is communicatively connected to multiple separately owned and managed. networks, referred to herein as provider networks **113** and **117** via network to network interfaces or ports (ENNIs) **114** and **116** respectively. The provider networks **113** and **117** are connected to consumer end points **111** and **119**. Provider networks **113** and **117** may themselves be comprised of subnetworks. As would be apparent to one of ordinary skill in the art, system **100** may include more than two provider networks.

[0015] Referring again to FIG. **1**, a system, computer or server **120** provides a portal application associated with, or capable of communicating with, the central service network.

The portal application provides the user with information regarding functionality, fault and performance management of the network. The user may access the portal via a client device **124**, such as computer, over a network **126**, such as the Internet. It should be noted that while a portal application operating on a server is described herein, other implementations to provide such functionality are possible and considered within the scope of this aspect. As will be described in more detail below, aspects of the systems and methods can be used for managing interconnection and service aspects amongst a plurality of external elements, such as the exemplary external elements described above. However, further description of the exemplary framework **100** and exemplary architecture will be helpful in understanding these aspects.

[0016] FIG. **2** illustrates exemplary connectivity and transport between edge locations **202** within a central service network, such as central service network **115**. As shown in FIG. **2**, connectivity between each of the edge locations **202** may be via direct transport to one or more of the other edge locations **202**, or it may also involve connection through one or more networks such as a third-party network **204** or a public network **206**, such as the Internet. Each of these edge locations **202** connects to and communicates with an external element, such as, for example, any of the elements described above. Thus, by way of example, the central service network facilitates connections, such as a data or telecommunications service connection, that a user may desire to a particular location outside the user's existing system or network.

[0017] For further context of exemplary architecture with respect to the edge locations, FIGS. **3**A, **3**B, **4**A and **4**B illustrate various edge location configurations that may be employed to provide connectivity to external elements with the understanding that any number of configurations known in the art may be employed. As shown in FIG. **3**A, an edge location may be configured as a single edge switch/router device, wherein the edge switch/router device is in communication with the central service network and is capable of or in communication with one or more external elements, thereby providing external connections for the benefit of the users of the central service network. As shown in FIG. **3**B, an edge location may be configured with two or more edge switches/router devices primarily for redundancy. In this configuration, each edge switch/router device is in communication with the central service network and is capable of or in communication with one or more external elements. The edge switches/router devices are also in communication with each other. As shown in FIG. **4**A, an edge location may be configured with a core router device separate from and in communication with an edge switch device. As shown in FIG. **4**B, an edge location may be configured with a core router device separate from and in communication with two or more edge switch devices for redundancy. In a particular implementation, the central service network is an Ethernet network which employs one or more Ethernet switches, which is preferably a multi-port switch module or an array of modules. The Ethernet switch may be, merely by way of example, one or more components from the 6500 Catalyst Series from Cisco Systems, Inc., which may include one or more supervisors, chassis configurations, modules, PC cards, as well as operating system software.

[0018] As previously mentioned, the central service network may provide connectivity to any number of external elements, including a plurality of application services. Such connectivity may be employed in any number of ways as known in the art. As shown in FIG. **4**, one or more application services may be accessible to a user via one or more edge location connections. Furthermore, one or more application services may be accessible within the central service network and connectable via a router/switch within the network. It is contemplated that one or more application services may be hosted by central service network for the benefit of network users.

[0019] As previously mentioned, according to a particular aspect, a system for identifying, analyzing and managing performance across the entire network, from end to end, is contemplated. The system includes the aforementioned network, which includes a plurality of edge connection points in communication with each other and each either in communication with or capable communicating with at least one of the plurality of external elements. Server **120**, which is in communication with the central service network, hosts a portal application accessible to manage performance, analysis and fault identification amongst the various elements. The portal application has visibility of the edge connection points and connected external elements to determine manageability of interconnection and service aspects for one or more selected external elements. The same server or another server may also have stored thereon a database containing data related to the network and or user profile and settings information.

[0020] While depicted schematically as a single server, computer or system, it should be understood that the term "server" as used herein and as depicted schematically herein may represent more than one server or computer within a single system or across a plurality of systems, or other types of processor based computers or systems. The server **120** includes at least one processor, which is a hardware device for executing software/code, particularly software stored in a memory or stored in or carried by any other computer readable medium. The processor can be any custom made or commercially available processor, a central processing unit (CPU), an auxiliary processor among several processors associated with the server **120**, a semiconductor based microprocessor (in the form of a microchip or chip set), another type of microprocessor, or generally any device for executing software code/instructions. The processor may also represent a distributed processing architecture.

[0021] The server operates with associated memory and can include any one or a combination of volatile memory elements (e.g., random access memory (RAM, such as DRAM, SRAM, SDRAM, etc.)) and nonvolatile memory elements (e.g., ROM, hard drive, tape, CDROM, etc.). Moreover, memory may incorporate electronic, magnetic, optical, and/or other types of storage media. Memory can have a distributed architecture where various components are situated remote from one another, but are still accessed by the processor.

[0022] The software in memory or any other computer readable medium may include one or more separate programs. The separate programs comprise ordered listings of executable instructions or code, which may include one or more code segments, for implementing logical functions. In the exemplary embodiments herein, a server application or other application runs on a suitable operating system (O/S). The operating system essentially controls the execution of the portal application, or any other computer programs of server **120**, and provides scheduling, input-output control, file and data management, memory management, and communication control and related services.

[0023] Within the central network is an Ethernet switch **110** sometimes referred to herein as a central network router, which is preferably a multi-port switch module or an array of modules, provides connectivity, switching and related control between one or more of the plurality of provider networks **113** and **117**. The switch **110** may be, merely by way of example, one or more components from the 6500 Catalyst Series from Cisco Systems, Inc., which may include one or more supervisors, chassis configurations, modules, PC cards, as well as operating system software. The Ethernet switch is typically associated with a connectivity service provider.

[0024] FIG. **6** is a schematic depiction of an exemplary network from a service operations and administration management perspective. A top level depiction of certain network elements is shown in level **210**. As shown therein, one or more customer premises equipment (CPE) **211** is communicatively connected to a first provider network **213**. The customer premises equipment may be any terminal and associated equipment located at the service provider customer's premises. The CPE may be connected via a demarcation point or demarcation device established in the premises to separate customer equipment from the equipment located in either the distribution infrastructure or central office of the communications service provider. The CPE may be comprised of devices such as, for example, and without limitation, routers, Network Interface Devices (NIDs), switches, residential gateways (RG), set-top boxes, fixed mobile convergence products, home networking adaptors, internet access gateways, or the like, that enable consumers to access the first service provider's network, which in some instances may be via a LAN (Local Area Network).

[0025] As shown in FIG. **6**, a first provider network **213** is communicatively connected to the central network **215**, via a first network to network interface **214**. The central network **215** is connected to a second provider network **217** via a second network to network interface **216**. The second provider network **217** is connected to a second CPE **219**.

[0026] While only two provider networks **213** and **217** are depicted in FIG. **6**, it will be apparent to one of skill in the art that multiple provider networks may be communicatively connected to the central network. Similarly, one of skill in the art will recognize that each provider network may be communicatively connected to multiple CPEs.

[0027] As shown in FIG. **6**, fault and performance management occur at a plurality of levels or domains, shown in FIG. **6** as items **220**, **230**, **240** and **250**. In an embodiment, such fault and performance management uses the Y.1731 or 802.1ag protocols, which are incorporated herein by reference. Other suitable protocols may be used as well. As shown in FIG. **6**, domain level 3, shown as item **220**, is used for monitoring the central network **215** having maintenance endpoints **222** and **224** at the interface of the central network **215** to the first and second network to network interfaces **215** and **216**. Domain level 4, shown as item **230**, is used to monitor the provider networks **213** and **217**, having a first maintenance end point **232** at the interface of the first provider network **213** to the first CPE **211** on one end and a second maintenance end point **234** at the interface of the first network to network interface **214** to the central network **215**. A third maintenance end point **236** is at the interface of the central network **215** to the second network to network interface **216** and a fourth maintenance end point **238** is at the interface of the second provider network **217** and the second CPE **219**. Domain levels 5 and 6 are used to monitor the network between the CPEs **211** and **219** and the central network **215**. This domain level has a first maintenance end point **241** at the first CPE **211** on one end and a second maintenance end point **244** between the first network to network interface **214** and the central network **215**. This domain level also has a third maintenance end point **245** on one end between the central network **215** and the second network to network interface **216** and a fourth maintenance end point **248** on the other end at the second CPE **219**. Domain levels 5 and 6 also have maintenance intermediate points **242**, **243**, **246** and **247**, located at the ends of the first and second provider networks. Domain level 7 is used to monitor the entire network from the first CPE **211** to the second CPE **219**, having a first maintenance end point at the first CPE **211** and a second maintenance end point at the second CPE **219**. Domain level 7 also has maintenance intermediate points **253** and **254** at the ends of the central network. The domain levels described herein are exemplary and an alternative domain level scheme may be used. For example domain level 5 instead of domain level 3 may be used for core network and domain level 3 may be used for the edge network.

[0028] The monitoring system provides a plurality of interactive displays to provide users with real time network fault and performance information. A first such interactive display, referred to as EVC browser pane display **300**, is shown in FIGS. **7** through **9**. The EVC browser pane display **300** displays information regarding the networks in a hierarchal manner. As shown in FIGS. **7**, **8** and **9** a first display level **310** displays the network, a second display level **320** shows the markets comprising the network **310**, which may be based on geographic areas, a third display level **330** shows a building address for buildings comprising the market **320**, a fourth display level **340** displays the network to network interfaces (ENNIs) or ports, a fifth display level **350** displays the service end points and a sixth level **360** displays the maintenance end points. Certain display levels may be collapsed or expanded to show or hide the sub levels thereunder. For example, a market can be expanded to show the building addresses that comprise that market. Each display entry on this view contains an alphanumeric identifier of a portion of the network. For example, for a building, the identifier may be the address of the building, whereas, for an ENNI/port, the identifier may be a circuit identification number. Similarly, an maintenance end point may include an identifier identifying the local and remote maintenance end points correlating thereto.

[0029] Display levels may also have a numeric sublevel indicator **370** adjacent the alpha-numeric identifier to identify the number of the sub portions of the network stemming therefrom. For example, as shown in FIG. **7**, on line **340**, the number "1" indicates that there is one service end point for the ENNI/Port identified on line **340**. For maintenance end points displayed on the sixth level **360**, there may also be displayed a domain level **380** indicator corresponding to the maintenance domain level corresponding to that maintenance end point.

[0030] In another aspect of the EVC browser pane display **300**, color coded error reporting is provided at multiple levels of the network. This allows a user to quickly pinpoint locations on the networks at which errors are occurring. As shown in FIGS. **9** and **10**, this can be accomplished by a variety of visual display tools including highlighting or the use of symbols. Different colors may be used to indicate different error locations. For example, a market highlighted red may indicate

an error in the central network, whereas a market highlighted orange may indicate an error at the provider or end customer network.

[0031] In another aspect of the EVC browser pane display, a plurality of functions for obtaining detailed information regarding specific portions of the network are provided. In one embodiment, these are provided by way of drop down menus **385** that appear when a user clicks on one of the alphanumeric identifiers for one of the network components. As shown in FIG. **11**, the identifier for a network to network interface may be clicked to provide a menu **385** of network to network interface assessment functions **386-388**. The following functions are available in the network to network interface menu: Link OAM discovery **386**, Link OAM statistics **387** and ENNI/Port details **388**. Link OAM is defined in IEEE 802.3ah standard, which is incorporated in its entirely herein by reference.

[0032] The Link OAM discovery function **386** enables a user to send an active link OAM discovery command to the central network router **110**. The discovery is then performed on the physical interface associated with specific ENNI. Usage of this function requires a Link OAM configuration to exist on the interface. As shown in FIG. **12**, the discovery process returns useful OAM information about remote as well as local peers: remote MAC address, OAM profile configuration, and OAM capabilities.

[0033] FIG. **13** shows a sample of the Link OAM status and statistics function results **390**. As shown in FIG. **13**, the Link OAM status and statistics function provides to the user statistics about link OAM status and protocol data unit (PDU) exchange. As shown in FIG. **13** it also provides information regarding notifications and loopbacks, as well as information regarding frames lost of fixed frames, errors detected on the link, number of errors detected locally, number of errors detected by the remote OAM peer, number of transmitted and received error/event notifications, number of transmitted and received MIB variable requests, number of transmitted and received unsupported OAM frames.

[0034] FIG. **14** shows a sample of the results **393** of the ENNI/Port details function **388**. As shown in FIG. **14**, the ENNI/Port details function provides the user with information related to the selected ENNI/Port, such as the maximum transmission unit (MTU), circuit identification, company name, link OAM profile name, and class of service (CoS) mapping information.

[0035] FIG. **15** shows a function menu **400** for a service end point also referred to herein as an EVC/OVC end point. As shown in FIG. **14** the service end point function menu provides multiple functions including a Pseudowire Ping function **401** and a Show Ethernet Service function **402**.

[0036] FIG. **16** shows the resultant display for a successful Pseudowire Ping **403**. The Pseudowire Ping function is one of the Active Fault Detection, Isolation, Diagnostics, and Verification (AFDIDV) toolset. It functions over the central network multiprotocol label switching (MPLS) backbone, giving the user an instant ability to ping the remote end of the EVC/OVC using layer 2 OAM frames only. This functionality verifies the OVC connectivity over the central network. A successful ping will clear a false alarm received on the OVC end point.

[0037] FIGS. **17-18** show exemplary displays of the Show Ethernet Service function. As shown in FIG. **17**, the Show Ethernet Service function provides a display of an end-to-end single EVC **600**. FIG. **17** shows a display for two end customers **601** and **602**, two provider networks **603** and **604**, and the central network backbone **605**. This display is based on the available OAM MEPs on the provider as well as the end customer devices. The links between the components of the network are displayed in a first color or other indicia, and in a particular embodiment the color green, when the links are operational and an OAM configuration exists. In the cases where the service provider or end customer does not provide peer MEPs, the corresponding links will be displayed in a second color or other indicia, and in a particular embodiment the color gray. FIG. **18** illustrates an exemplary display in which the providers **603** and **604** are peering with central network **605** on level 4; however the end customers **601** and **602** are not peering at level 5. In the case of a network fault, the link corresponding to the portion of the network having the fault may be displayed in a third color or other indicia, and in a particular embodiment the color red, thereby providing a visual indication of the location of the fault.

[0038] As shown in FIG. **19**, another function menu, namely an MEP function menu **630**, is provided for the maintenance end points **360**. Clicking on any of the active MEPs displayed in the EVC browser pane display will invoke the MEP function menu **630**. As described in more detail below, the MEP function menu lists functions that can be performed on each MEP. As shown in FIG. **19**, in this particular embodiment, the CFM loopback, CFM Link Trace and CFM status functions are provided.

[0039] The "CFM loopback" function **631** can be used to verify remote end connectivity. This function initiates a plurality of CFM LBMs (loopback messages) from the selected local MEP to a targeted remote MEP. As shown in FIG. **20**, in the case of a multipoint circuit, a user can select the targeted remote MEP from a drop-down box **635**. The remote MEP responds by sending a loopback response (LBR) per each LBM received. If LBMs are successfully sent and a predetermined acceptable number of LBRs are received back, a fault displayed on the OVC will considered as false alarm or due to configuration reasons that do not affect network connectivity and therefore the fault will be cleared. For example if 5 LBMs are sent and 3 or more LBRs are received, the fault will be cleared. As shown in FIGS. **21** and **22**, once the CFM loopback function is performed, the interface may display the results of the loopback including a success rate showing the number and percentage of LPR's received **640**, as well as the time for the minimum, average and maximum round trip loopbacks **641**, **642** and **643**, respectively.

[0040] As shown in FIG. **19**, the CFM Link Trace function **632** may also be provided in the MEP function menu **630**. This CFM Link Trace function **632** initiates an Ethernet CFM link trace operation on the selected MEP. When a user clicks on this function, a Link Trace Message (LTM) is sent from the MEP on the router interface where the MEP is configured to the selected target remote MEP. If the link trace is successful, a link trace reply (LTR) is received back from the target MEP. In addition, all the Maintenance Intermediate Points (MIPs) on the path to the MEP will send LTRs as well. This mechanism may be used to isolate the faulty portion of the network. As shown in FIG. **23**, the CFM Link Trace function provides an output display **650**. The output display **650** shows the number of hops for each link trace reply **651**. A hop means the LTM message was captured by a MIP or MEP and a LTR response has been sent back to the originating MEP. Other output information displayed may include the time and the date of the link trace **652**, an identifier of the ingress medium

access controller (MAC) **653**, an identifier of the egress MAC **654** of all of the MIPs and MEPs responding to the LTM, and an identifier of the relay **655**. In addition, the output display identifies the number of link trace replies dropped **653**, if any.

[0041] As shown in FIG. **19**, the CFM Status function **633** may also be provided in the MEP function menu **630**. This function may be used to collect status and statistic information from the selected local MEP. As shown in FIG. **24**, the CFM status function provides an output display **660**. The output display contains a MEP status indicator **662** indicating the status of the remote MEP, an identifier of the remote MEP **664**, an identifier of the MAC for the remote MEP **666**, and an indicator of the status of the port corresponding to the remote MEP **668**. The output display may also provide an identifier of the local MEP **670**. The statistics are based on the continuity check messages (CCMs) exchanged with the remote MEP. The output also may show errors **672**, out-of-sequence CCMs **674**, and remote defect indication (RDI) errors **676**, such as a receive signal failure at a downstream MEP. Advantageously, for networks having multiple peer MEPs, the output display **660** for the CFM status function will return the status of all remote peer MEPS **678** as shown in FIG. **25**.

[0042] A second interactive display referred to as a graphical pane display **700** is shown in FIG. **26**. The graphical pane display **700** presents a geographic overview of the various circuits **702**. An exemplary geographic pane showing connections in North America is shown in FIG. **26**; however, the geographic pane may display connections worldwide, or in any subgeographic configuration.

[0043] As shown in FIG. **27**, the geographic pane has a main display portion **710**, which shows the EVC portion on the central network backbone (tail segments or segments between the service provider and the CPE are not shown). In the embodiment shown, sites **704** are depicted by dots and connections between the sites are depicted by lines **706** connecting the dots. Only one line is shown between each of the two sites that has OVC end points and the actual number of OVCs between any two sites **704** is displayed numerically next to the line **710**.

[0044] The geographic pane display provides a visual indicator of faults occurring on any given EVC. When a fault occurs on any portion of an EVC, the graphical display will reflect the fault on the corresponding OVC by changing the appearance of the trace line. For example, the trace line may normally appear black and change to red to indicate a fault. In addition, the display of the number of OVCs displayed on the line may be changed to indicate a fault. For example, as shown in FIG. **26**, a second number may be shown to indicate the number of faulty OVCs. This number is preferably displayed in a different color, such as red, than the number indicating the total number of OVCs. The appearance of the dot representing the site that reports the problem may also be altered to indicate a fault, for example, by changing the color of the dot to red. The display may also provide a visual indicator to identify situation in which a fault has occurred only on a local connection. For example, the display may change the color of the site dot, but may not change the color of the line where the only fault has occurred locally meaning within the same market, or same router.

[0045] Also provided in the graphic pane display is a visual indicator **730** of the status of connectivity of the system server and the application providing the user display, i.e. the web browser. This visual indicator is referred to herein as the "heartbeat indicator." The heartbeat indicator provides a visual real-time verification of the user's connection to the system server. In the embodiment shown in FIG. **26**, the heartbeat indicator uses a row of bars to indicate the status of the connectivity; however, one of skill in the art will appreciate that other symbols may be used, such as, for example, vertical bars, horizontal bars, or other shapes. Each time increment, for example, one second, the heartbeat indicator displays a subsequent bar. If the connection is active the bar has a first appearance, for example, a blue color. If, on the other, hand, the connection is inactive, the bar has a second appearance, for example, a red color.

[0046] The heartbeat indicator has a refresh interval, for example, 30 seconds, after which the web browser will attempt to connect to the system server. The refresh interval may be set by the user. If the connection is successful, the browser will update the contents of the display and the indicator will be reset to zero. If, on the other hand, the browser is not able to connect to the server, the indicator, i.e., the bars, will indicate an inactive connection. Optionally, if the browser is not able to connect to a server for a predetermined second interval, for example twenty seconds, the entire indicator may take on the appearance that indicates an inactive connection. For example, the entire indicator may become red to indicate an ongoing loss of connectivity.

[0047] The map portion **710** of the graphical pane may also have a secondary visual indicator to indicate the loss of connectivity. For example, a loss of connectivity may change the color of the background of the map from white to red.

[0048] The map portion **710** of the graphical pane is also navigable via a zoom feature and a pan feature. The map portion of the graphical pane also permits additional user controls and displays. For example, the map portion of the graphical pane includes allows the user to save certain layouts and recall those layouts at a later time. In addition, a user can face alter the display of certain routes. For example, a user could "fade" or minimize the appearance of EVCs that do not have faults.

[0049] A third display, referred to herein as the event pane display **800**, is shown in FIG. **28**. The event pane display provides a tabular display of events. Associated with each event may be an event identifier **802**, such as a number. Additional information relating to each event may also be provided within the tabular display. For example, as shown in FIG. **28**, an identifier of the market **804**, an identifier of the OVC/EVC circuit in which the event occurred **806**, an identifier of the end points associated with the circuit **808**, the time of the event **810** and the time that the event was last modified **812**, as well as a status indicator **814** indicating whether the circuit is up or down may all be displayed.

[0050] Within the tabular display, different categories or types of events may be identified by different indicia correlating to the location of the event. For example, central network and link OAM faults, such as CFM faults occurring on level 3, psuedowire faults on the central network, and both the logical interface or sub-interface faults, as well as physical interface faults occurring on the central network, and a "down" condition for a link OAM session, may be identified by a first indicia, such as the color red. Faults detected outside of the central network, such as CFM level 4 and level 5 faults, may be identified by a second indicia, such as the color orange. in one embodiment, cleared faults may be identified by a third indicia such as the color green. The system may be configured to remove any display of the cleared faults after a set time interval.

[0051] In addition to or in place of such color coding, a second set of fault identifying indicia may be provided. For example, different alpha-numeric fault codes **816** may be used to identify the following types of events: faults detected by the psuedowire monitoring facility; faults detected by the physical and logical interface monitoring facility; faults detected by the Link OAM (802.3ah) monitor; faults detected by the CFM monitor on maintenance domain level 3 regarding the central network backbone; faults detected by the CFM monitor on maintenance domain level 4 (the service provider domain); faults detected by the CFM monitor on maintenance domain level 5 (the customer domain); and faults detected manually by performing a CFM loopback or psuedowire ping that resulted in a failure. The fault codes may also be color coded, such that when the fault is resolved, the appearance of the fault code changes, for example, from red to green.

[0052] The fault codes may also be dynamic and linked to additional information, so that clicking on a red fault code will display the certain information relating to the fault as received from the monitoring facility. For example, as shown in FIG. **29**, the date and time that the fault occurred, an address or other identifier of the location at which the fault occurred, and information regarding the type of fault may be displayed in a fault information display **820**. Similarly as shown in FIG. **30**, clicking on a green fault clearing code **818** will result in a fault clearing display **830** showing information regarding the event that cleared the fault and certain information relating to that event. For example, the date that the event occurred, the nature of the event that cleared the fault, the current status, and/or whether there are other errors may be displayed.

[0053] If multiple events/messages are received on the same EVC, the same entry will be updated by adding event codes (either fault codes, or fault clearing codes) and updating the "Time Modified" field.

[0054] The event pane display may also be searchable, enabling a user to search for a particular event, as shown in FIG. **31**.

[0055] As shown in FIG. **32**, the EVC browser pane also provides a matrix display **900** for showing users information regarding multipoint any-to-any (such as e-LAN and c-TREE) services. The multipoint view may be accessed by clicking a multipoint MEP **360** in the graphical pane view **300**. As shown in FIG. **32**, the end points of the multipoint circuit are listed across the vertical axis **902** and horizontal axis **904** of the matrix display **900**. Body cells of the matrix **908** contain indicia identifying the status of the connectivity of the particular circuits between the end points. For example, as shown in FIG. **32**, a mesh containing up-looking triangles (Δ) **910** indicating an up MEP covering the central network. These indicia may also be color coded or bear some another identification indicating the status of that network. For example, a red color may be used to indicate an MEP detected network error, whereas a green color may be used to indicate an MEP that does not have any errors. The indicia are also dynamic such that they are clickable and linked to the MEP function menu for that MEP, which, as discussed above provides a user with access to perform loopback, link trace, and show CFM statistics and status functions.

[0056] As shown in FIG. **33**, the matrix also allows a user to open an end to end view display **600** for each connection of the multipoint circuit. A user can click on a square **912** associated with a certain cell **908** of the matrix **900** to open a display **600** showing the end to end view for the circuit corresponding to that cell. Once the icon is clicked and the end to end view is displayed, an indicator may appear in the cell to identify the cell for which the end to end view has been displayed. For example, the color of the square in the selected cell may be changed. The visual appearance of the cells may also be altered to indicate a network error. For example, as shown in FIG. **33** the background color of the cells **908** may be changed from white to yellow in cells corresponding to a network experiencing an error.

[0057] As shown in FIG. **34**, the down MEPS looking towards the provider and customer (level 4 and level 5) may be displayed using indicia different than the indicia used for the up MEPS. For example, as shown in FIG. **34**, they may be identified by down-looking triangles **914** and will be places in the diagonal cells **916** (which correspond to the port intersection with itself.)

[0058] The system also provides for communication of events to a predetermined set of email recipients. A user can input a list of addresses, such as email addresses, for the users to whom communications are to be sent. The user can also designate a certain interval at which communications regarding event information is sent to the list. In addition, the user can save this list to the system server, so that it can be used each time the user logs in. Alternatively, the user can save the list so that it is used for that session only.

[0059] As shown in FIGS. **35-42** the system also provides performance management features. One aspect of the performance management feature provides for a performance management configuration display **1000** for creation of a user customized report regarding system performance over a user designated time period. As shown in FIG. **35** a user may configure the report by selecting the start time **1002** and end time **1004** for the reporting period from fields within the display **1000**. The user may also select a plurality of circuits that for which data will be collected and reported upon, by designating the market **1006**, address **1008**, network to network interface or port **1010**, and OVC/EVC **1012** for the selected circuits. As shown in FIG. **36**, the report may display graphical data regarding per-EVC utilization **1020**, per-EVC round trip delay **1022**, per-EVC jitter **1024** and per-EVC frame loss **1026** in graphical form.

[0060] Along with the graphs showing the data, the performance management function also displays an end to end view of the circuit **600**, which enables a user to break down the end-to-end performance statistics into segments corresponding to each portion of the total link. As shown in FIG. **37**, a user may click on a specific segment link. For example FIG. **37** shows a display where a user has selected the link **1030** from the central network to the end user A, and so only performance data relating to that segment is displayed. The selected portions may be highlighted in a different color to show what segment is being displayed. The aggregation of these statistics provides the end-to-end SLA.

[0061] As shown in FIGS. **38**, the display also provides a clickable link **1050** for a user to review the tabular data **1052**, shown in FIG. **39**, used to construct each graph.

[0062] The implementation of this performance management is based on Y.1731 standard protocol. As this standard is applied in the certain aspects disclosed herein, unique implementation allows for end-to-end as well as per-segment SLA monitoring and service assurance for individual EVCs.

[0063] As shown in FIG. **40**, the system can also display ENNI (port) aggregate utilization **1060**. A user can select this

display option by, clicking the "ENNI utilization only checkbox" **1062** and selecting the desired ENNI/Port **1010**.

[0064] The system also provides for the graphical display of performance statistics for multipoint networks, as shown in FIG. **41**. After a user selects a desired market, address, ENNI/port, EVC ID, the user can select one or more target end point(s) **1064**.

[0065] As shown in FIG. **42**, the system also provides for on-demand service level monitoring. By clicking on the desired source MEP on the detailed EVC/OVC view, the system provides user the user with a display **1080** of the key performance data including delay, round trip delay and frame loss.

[0066] The system also provides for the generation of automatic alerts to notify users when performance indicators surpass or drop below user-defined pre-determined alarm set points. The user can provide the alarm set points for certain data, such as per ENNI/Port Input traffic (Mbps) and per ENNI/Port Output traffic (Mbps). Users can also set alarm set points for Per OVC/EVC Input traffic (Mbps), Output traffic (Mbps), Delay (RID), Jitter and Frame loss, Users can provide one or more addresses, such as email addresses, to which notifications are sent by the system when monitored data exceeds a pre-set alarm point.

[0067] While one or more specific embodiments have been illustrated and described in connection with the invention(s), it is understood that the invention(s) should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with later appended claims.

1. A system for diagnostic, performance and fault management of a network, the system comprising:

a central network in communication with a first provider network associated with a first party and comprising a plurality of network elements, and a second provider network associated with a second party and comprising a plurality of network elements, wherein the central network is not associated with the first or second party; and

a server within the central network, the server running an application accessible by a user via a client device, wherein the application allows the user to access, through the central network, and display on the client device, one or more of connectivity data, event data, network element data, and performance data associated with at least a portion of either one or both of the first and second provider networks.

2. The system of claim **1**, wherein the application is capable of end-to-end visibility between any two of a plurality of network elements within the first and second provider networks.

3. The system of claim **1**, wherein the application allows the user to customize the display of the accessed data.

4. The system of claim **1**, wherein the application allows the user to configure a notification of a change in one or more of the connectivity data, event data, network element data, and performance data.

5. The system of claim **4**, wherein the notification is an application alert.

6. The system of claim **4**, wherein the notification is an electronic communication to a device.

7. The system of claim **1**, wherein the application allows the user to select a portion of either one or both of the first and second provider networks for which to access and display data.

8. The system of claim **7**, wherein the user selects the portion by selecting a first point within one of the first and second provider networks and a second point within one of the first and second provider networks to define a segment.

9. The system of claim **1**, wherein the application allows the user to select at least one of a plurality of domain levels amongst the first and second provider networks for which to display the accessed data.

10. A method for diagnostic, performance and fault management of a network, using a processor of a device within a central network, the method comprising:

receiving a request, at the processor, from a user device to access connectivity data, event data, network element data, or performance data associated with at least a portion of one or both of a first provider network associated with a first party and a second provider network associated with a second party, wherein the central network is not associated with the first or second party;

accessing the requested data, by the processor, in response to the request;

facilitating display of the requested data on the user device, using the processor; and

allowing the user to customize the display of the requested data, using the processor.

11. The method of claim **9**, further comprising facilitating selection by the user of a portion of either one or both of the first and second provider networks for which to access and display the requested data, using the processor.

12. The method of claim **9**, further comprising facilitating end-to-end visibility to the user between any two of a plurality of network elements within the first and second provider networks, using the processor.

13. The method of claim **9**, further comprising facilitating selection by the user of at least one of a plurality of domain levels amongst the first and second provider networks for which to access and display the requested data, using the processor.

14. A computer program product stored on a non-transitory computer-readable medium, the computer program product having computer-executable code instructions which are executable on a computer server to facilitate diagnostic, performance and fault management of a network through a client device, the computer-executable code instructions comprising:

first code instructions for receiving a request from a user device to access connectivity data, event data, network element data, or performance data associated with at least a portion of one or both of a first provider network associated with a first party and a second provider network associated with a second party, wherein the central network is not associated with the first or second party;

second code instructions for accessing the requested data in response to the request;

third code instructions for facilitating display of the requested data on the user device; and

fourth code instructions for allowing the user to customize the display of the requested data.

15. The computer program product of claim **12**, the computer-executable code instructions further comprising fifth code instructions for facilitating selection by the user of a portion of either one or both of the first and second provider networks for which to access and display data.

16. The computer program product of claim **12**, the computer-executable code instructions further comprising fifth

code instructions for facilitating end-to-end visibility to the user between any two of a plurality of network elements within the first and second provider networks.

17. The computer program product of claim **12**, the computer-executable code instructions further comprising fifth code instructions for facilitating selection by the user of at least one of a plurality of domain levels amongst the first and second provider networks for which to access and display the requested data.

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