IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SPRINT COMMUNICATIONS COMPANY L.P., Plaintiff,	)	
v.	)	C.A. No.: 1:12-cv-01013-RGA
COMCAST CABLE COMMUNICATIONS, LLC and COMCAST IP PHONE, LLC, Defendants.	)	**DEMAND FOR JURY TRIAL**

SPRINT'S ORIGINAL COMPLAINT

Plaintiff Sprint Communications Company L.P. ("Sprint") for its complaint of patent infringement against Defendants Comcast Cable Communications, LLC ("Comcast Cable") and Comcast IP Phone, LLC ("Comcast Phone") (collectively, "Comcast") alleges as follows:

THE PARTIES

1. Plaintiff Sprint Communications Company L.P. is a limited partnership organized and existing under the laws of the State of Delaware, with its principle place of business at 6200 Sprint Parkway, Overland Park, Kansas 66251.

2. On information and belief, Defendant Comcast Cable is a Limited Liability Company organized and existing under the laws of the State of Delaware, with its principal place of business at One Comcast Center, 1701 JFK Blvd., Philadelphia, Pennsylvania 19103-2838.

3. On information and belief, Defendant Comcast Phone is a Limited Liability Company organized and existing under the laws of the Commonwealth of Pennsylvania, with its principal place of business at One Comcast Center, 1701 JFK Blvd., Philadelphia, Pennsylvania 19103-2838. Defendant Comcast Phone does business in this Judicial District and has appointed Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, Delaware, 19801

as its registered agent.

4. On information and belief, Comcast, including without limitation Comcast Cable, Comcast Phone, or one or more of their affiliates, provide and participate in providing by selling or by offering for sale Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play products and services.

5. On information and belief, Comcast, including without limitation Comcast Cable, Comcast Phone or one or more of their affiliates, use or participate in the use of Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play products and services.

SUBJECT MATTER JURISDICTION

6. This action arises under the United States patent laws, 35 U.S.C. §§ 101, *et seq*. The Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331 and 1338(a).

PERSONAL JURISDICTION

7. Comcast Cable and Comcast Phone transact business within the Judicial District, including selling, offering for sale, and using in this Judicial District one or more of Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play products and services. Comcast Cable and Comcast Phone have represented that they will not contest personal jurisdiction in Delaware for purposes of this action. The Court therefore has personal jurisdiction over Comcast Cable and Comcast Phone.

VENUE

8. Venue for Sprint's claims is proper in this Court pursuant to 28 U.S.C. §§ 1391 and 1400(b).

JOINDER

9. Joinder of at least Comcast Cable and Comcast Phone is proper under 35 U.S.C. § 299 because Sprint's allegations of patent infringement contained herein arise out of the same series of transactions or occurrences relating to the making, using, offering for sale, or selling within the United States, or importing into the United States, of the same and other products and services offered by these Comcast entities (or other affiliates identified in litigation). These claims further involve common questions of fact, including, but not limited to, the operation of Comcast's accused products and services, Comcast's use of any of Sprint's patented technologies, whether and to what extent Comcast's alleged infringement caused Sprint to lose profits, the level of ordinary skill in the art for the asserted Sprint patents, Comcast's policy (or lack thereof) for licensing intellectual property, Comcast's profits on its use of any allegedly infringed claims, and so on.

FACTUAL BACKGROUND
(The Patents-In-Suit)

10. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 5,742,605 ("the '605 patent") entitled "Synchronous Optical Network Using a Ring Architecture," which duly and legally issued in the name of Charles William Norman, Jr. on April 21, 1998. A true and correct copy of the '605 patent is attached as Exhibit A.

11. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,108,339 ("the '339 patent") entitled "Synchronous Optical Network Using a Ring Architecture," which duly and legally issued in the name of Charles William Norman, Jr. on August 22, 2000. A true and correct copy of the '339 patent is attached as Exhibit B.

12. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,452,931 ("the '931 patent") entitled "Synchronous Optical Network Using a

Ring Architecture," which duly and legally issued in the name of Charles William Norman, Jr. on September 17, 2002. A true and correct copy of the '931 patent is attached as Exhibit C.

13. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 6,870,832 ("the '832 patent") entitled "Telecommunications Provider Agent," which duly and legally issued in the names of Abdullah Murat Bog, Steven Turner, Matthew Kung-Wei Jonathan Barrow, and Tracey Mark Bernath on March 22, 2005. A true and correct copy of the '832 patent is attached as Exhibit D.

14. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 8,121,028 ("the '028 patent") entitled "Quality of Service Provisioning for Packet Service Sessions in Communication Networks," which duly and legally issued in the names of Matthew C. Schlesener, Pallavur Sankaranaraynan, and Brian D. Mauer on February 21, 2012. A true and correct copy of the '028 patent is attached as Exhibit E.

15. Sprint is the owner by assignment of all right, title, and interest in and to United States Patent No. 5,793,853 ("the '853 patent") entitled "System and Method for Recording Billing Information for a Telecommunications Service Request," which duly and legally issued in the name of Daniel Charles Sbisa on August 11, 1998. A true and correct copy of the '853 patent is attached as Exhibit F.

(Comcast)

16. Upon information and belief, Comcast is the largest cable operator in the United States, providing cable television, broadband Internet, and telephone service to both residential and commercial customers.

17. Upon information and belief, Defendant Comcast Cable and its operating subsidiary companies own and operate cable systems and sell, market, offer for sale, and provide

video, phone, and internet products and services in various markets across the United States.

18. Upon information and belief, Defendant Comcast Phone sells, markets, offers for sale, and provides packet-based telephony products and services in various markets across the United States.

19. Upon information and belief, within this Judicial District, Comcast has made, used, offered to sell, or sold Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play.

20. Upon information and belief, Comcast has made, used, offered to sell, or sold, and continues to make, use, offer to sell, or sell XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play that use Sprint's patented innovations, including Sprint's proprietary synchronous optical networking, call handling and processing, software updating, quality management, and records management technologies.

COUNT 1: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 5,742,605)

21. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–20 above.

22. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the '605 patent by making, using, selling, and offering for sale products and services using synchronous optical network having spans of different rings stacked within a single fiber route, including, for example only, Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play, that infringe one or more claims of the '605 patent.

23. Upon information and belief, Comcast Cable and Comcast Phone's infringement of the '605 patent will continue unless enjoined by this Court.

24. As a direct and proximate consequence of Comcast Cable and Comcast Phone's infringement of the '605 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 2: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 6,108,339)

25. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–24 above.

26. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the '339 patent by making, using, selling, and offering for sale products and services using synchronous optical network having a first ring occupying a physical route and a second ring that shares at least a portion of the physical route with the first ring, including, for example only, Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play products and services, that infringe one or more claims of the '339 patent.

27. Upon information and belief, Comcast Cable and Comcast Phone's infringement of the '339 patent will continue unless enjoined by this Court.

28. As a direct and proximate consequence of Comcast Cable and Comcast Phone's infringement of the '339 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 3: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 6,452,931)

29. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–28 above.

30. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the '931 patent by making, using, selling, and offering for sale

products and services using synchronous optical network having rings sharing at least a portion of the same physical route, including, for example only, Comcast's XFINITY Voice, XFINITY TV, XFINITY Internet, XFINITY Double Play, and XFINITY Triple Play products and services, that infringe one or more claims of the '931 patent.

31. Upon information and belief, Comcast Cable and Comcast Phone's infringement of the '931 patent will continue unless enjoined by this Court.

32. As a direct and proximate consequence of Comcast Cable and Comcast Phone's infringement of the '931 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 4: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 6,870,832)

33. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–32 above.

34. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the '832 patent by making, using, selling, and offering for sale products and services using a communication system and network elements in communication with a communication hub that receives a software agent, including Comcast's XFINITY Voice, XFINITY Double Play, and XFINITY Triple Play products and services, that infringe one or more claims of the '832 patent.

35. Upon information and belief, Comcast Cable and Comcast Phone's infringement of the '832 patent will continue unless enjoined by this Court.

36. As a direct and proximate consequence of Comcast Cable and Comcast Phone's infringement of the '832 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 5: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 8,121,028)

37. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–36 above.

38. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the ‘028 patent by making, using, selling, and offering for sale products and services using a communication system having a policy system that determines a quality level for a session, including Comcast’s XFINITY Voice, XFINITY Double Play, and XFINITY Triple Play products and services, that infringe one or more claims of the ‘028 patent.

39. Upon information and belief, Comcast Cable and Comcast Phone’s infringement of the ‘028 patent will continue unless enjoined by this Court.

40. As a direct and proximate consequence of Comcast Cable and Comcast Phone’s infringement of the ‘028 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

COUNT 6: PATENT INFRINGEMENT
(Infringement of U.S. Patent No. 5,793,853)

41. Sprint realleges and incorporates by reference the allegations set forth in Paragraphs 1–40 above.

42. Upon information and belief, Comcast Cable and Comcast Phone have been, and currently are, directly infringing the ‘853 patent by making, using, selling, and offering for sale products and services with a telecommunications network that merges primary and secondary records to form a single record, including Comcast’s XFINITY Voice, XFINITY Double Play, and XFINITY Triple Play products and services, that infringe one or more claims of the ‘853 patent.

43. Upon information and belief, Comcast’s infringement of the ‘853 patent will

continue unless enjoined by this Court.

44. As a direct and proximate consequence of Comcast's infringement of the '853 patent, Sprint has suffered and will continue to suffer irreparable injury and damages in an amount not yet determined for which Sprint is entitled to relief.

PRAYER FOR RELIEF

Wherefore, Sprint requests entry of judgment in its favor and against Comcast Cable and Comcast Phone as follows:

A. Enter judgment that Comcast Cable and Comcast Phone have infringed one or more claims of Sprint's Patents;

B. For damages to compensate Sprint for Comcast Cable and Comcast Phone's infringement of one or more claims of Sprint's Patents pursuant to 35 U.S.C. § 284, together with interest and costs as fixed by the Court;

C. Enter a permanent injunction restraining and enjoining Comcast Cable and Comcast Phone, and their respective corporate parents, corporate subsidiaries, corporate affiliates, their officers, agents, servants, employees, attorneys, and those persons in active concert or participation with Comcast Cable and Comcast Phone who receive actual notice of the order by personal service or otherwise, from any further sales or use of their infringing products or services and any other infringement of Sprint's Patents; and

D. For such other and further relief as the Court may deem just, proper, and equitable under the circumstances.

DEMAND FOR A JURY TRIAL

Sprint respectfully demands a trial by jury on all claims and issues so triable.

Dated: August 24, 2012

/s/ Richard K. Herrmann

Richard K. Herrmann (#405)
Mary B. Matterer (#2696)
MORRIS JAMES LLP
500 Delaware Ave., Suite 1500
Wilmington, DE 19801-1494
T: 302.888.6800
F: 302.571.1750
rherrmann@morrisjames.com
mmatterer@morrisjames.com

Of Counsel

B. Trent Webb (*pro hac vice*)
Bart A. Starr (*pro hac vice*)
Aaron Hankel (*pro hac vice*)
Ryan Schletzbaum (*pro hac vice*)
SHOOK, HARDY & BACON LLP
2555 Grand Boulevard
Kansas City, Missouri 64108-2613
T: 816.474.6550
F: 816.421.5547

Robert Reckers (*pro hac vice*)
Matthew Broaddus (*pro hac vice*)
Jared Tong (*pro hac vice*)
SHOOK, HARDY & BACON LLP
JPMorgan Chase Tower
600 Travis Street
Suite 1600
Houston, Texas 77002-2992
T: 713.227.8008
F: 713.227.9508

Attorneys for Sprint Communications Company L.P.

EXHIBIT A

US005742605A

United States Patent [19]

Norman, Jr.

[11] **Patent Number: 5,742,605**

[45] **Date of Patent: Apr. 21, 1998**

[54] **SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE**

[75] Inventor: **Charles William Norman, Jr.**, Overland Park, Kans.

[73] Assignee: **Sprint Communications Co., L.P.**, Kansas City, Mo.

[21] Appl. No.: **203,165**

[22] Filed: **Feb. 28, 1994**

[51] **Int. Cl.**[6] **H04L 12/50**; H04L 12/56

[52] **U.S. Cl.** **370/405**

[58] **Field of Search** 370/85.5, 85.1, 370/85.12, 85.13, 85.14, 16.1, 16, 401, 402, 404, 405, 406, 407; 340/825.5, 825.05, 827; 371/8.1, 11.1; 359/114, 118, 119, 124

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Ching, Yau–Chau, et al. "Where is SONET?," *IEEE LTS*, pp. 44–51, Nov. 1991.

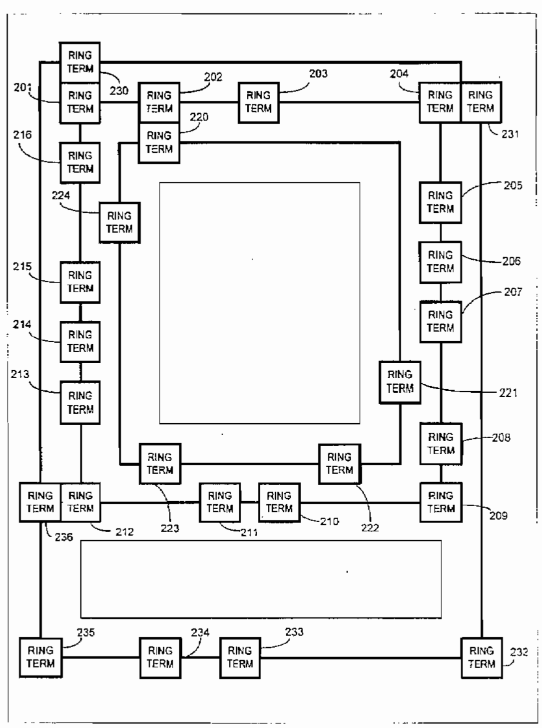
Haque, Izaz, et al., "Self–Healing Rings in a Synchronous Environment," *IEEE LTS*, pp. 30–37, Nov. 1991.

Primary Examiner—Douglas W. Olms
Assistant Examiner—Ajit Patel
Attorney, Agent, or Firm—Harley R. Ball; Jed W. Craven; Michael J. Setter

[57] **ABSTRACT**

The present invention is a SONET system for use in large geographic areas, such as areas encompassed by an IXC network, or which are larger than a LATA or a metropolitan area. The system uses self-healing rings which are interconnected. Some of the rings are stacked within the same physical routes in order to minimize the number of ring terminals on each ring.

49 Claims, 6 Drawing Sheets



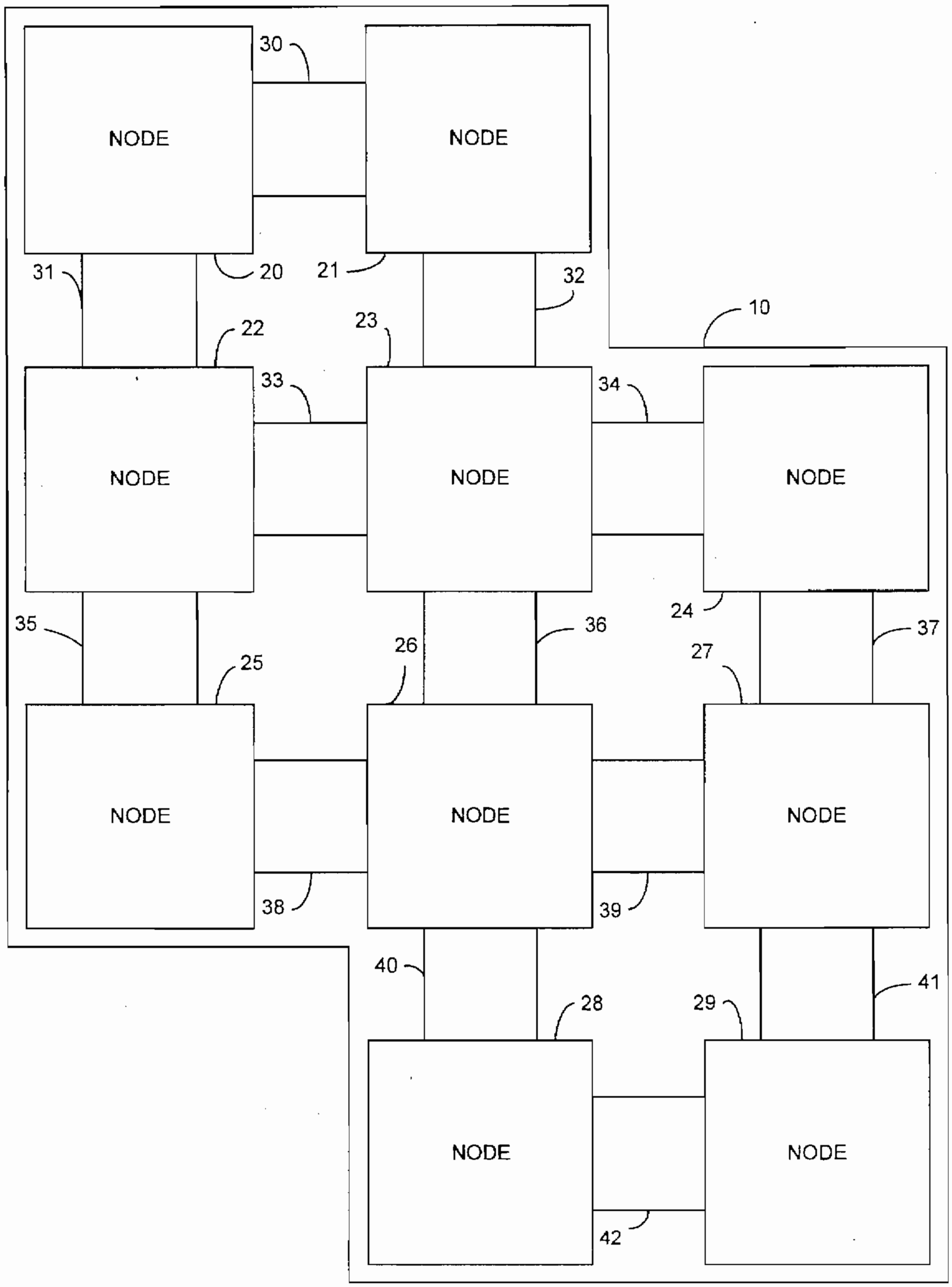


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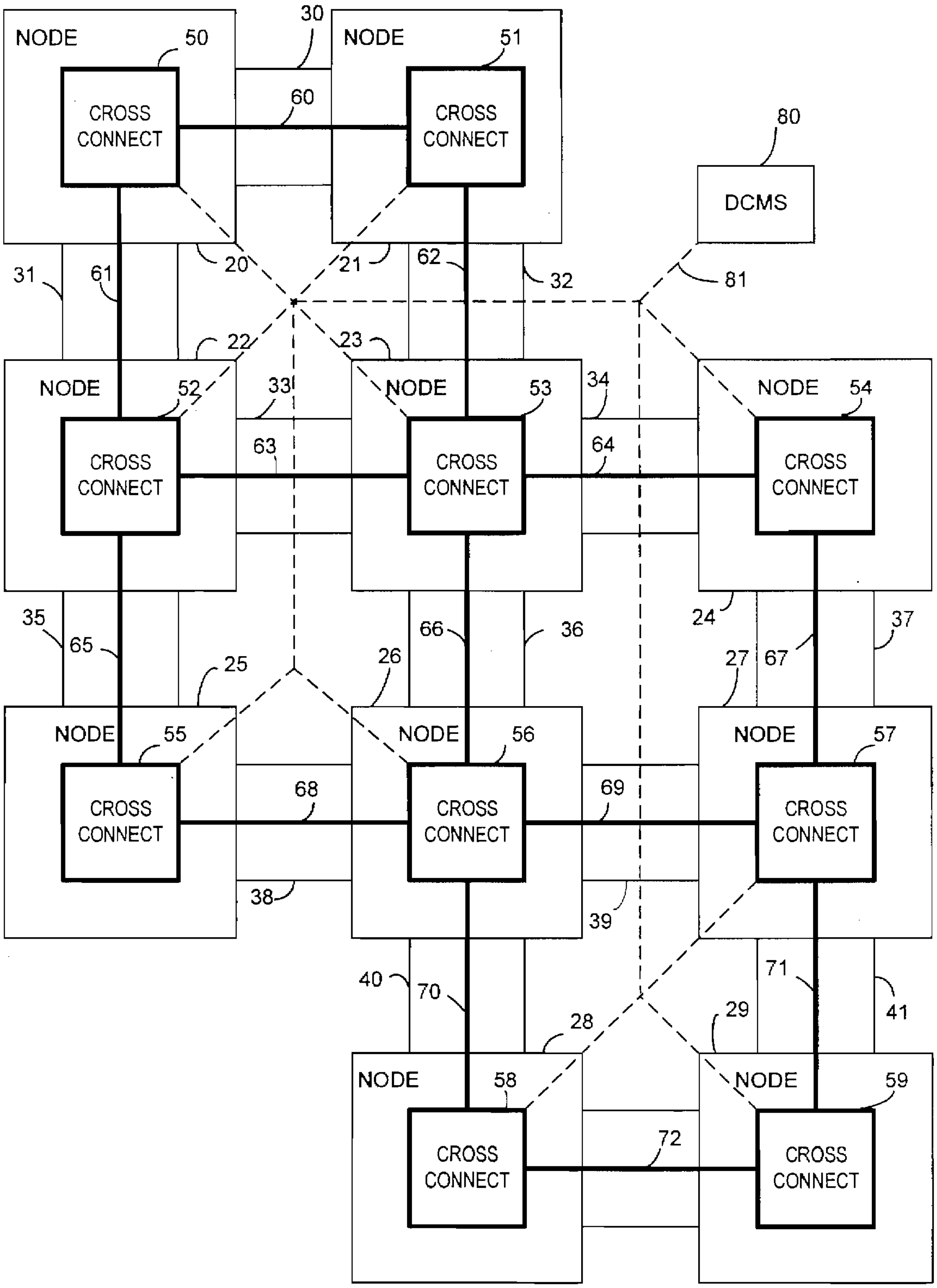
FIG. 1



NODE
50
CROSS CONNECT
30
60
NODE
51
CROSS CONNECT
80
DCMS
81
20
21
62
32
31
61
22
23
NODE
52
CROSS CONNECT
33
63
NODE
53
CROSS CONNECT
34
64
NODE
54
CROSS CONNECT
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36
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37
27
67
NODE
55
CROSS CONNECT
68
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56
CROSS CONNECT
69
NODE
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CROSS CONNECT
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71
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28
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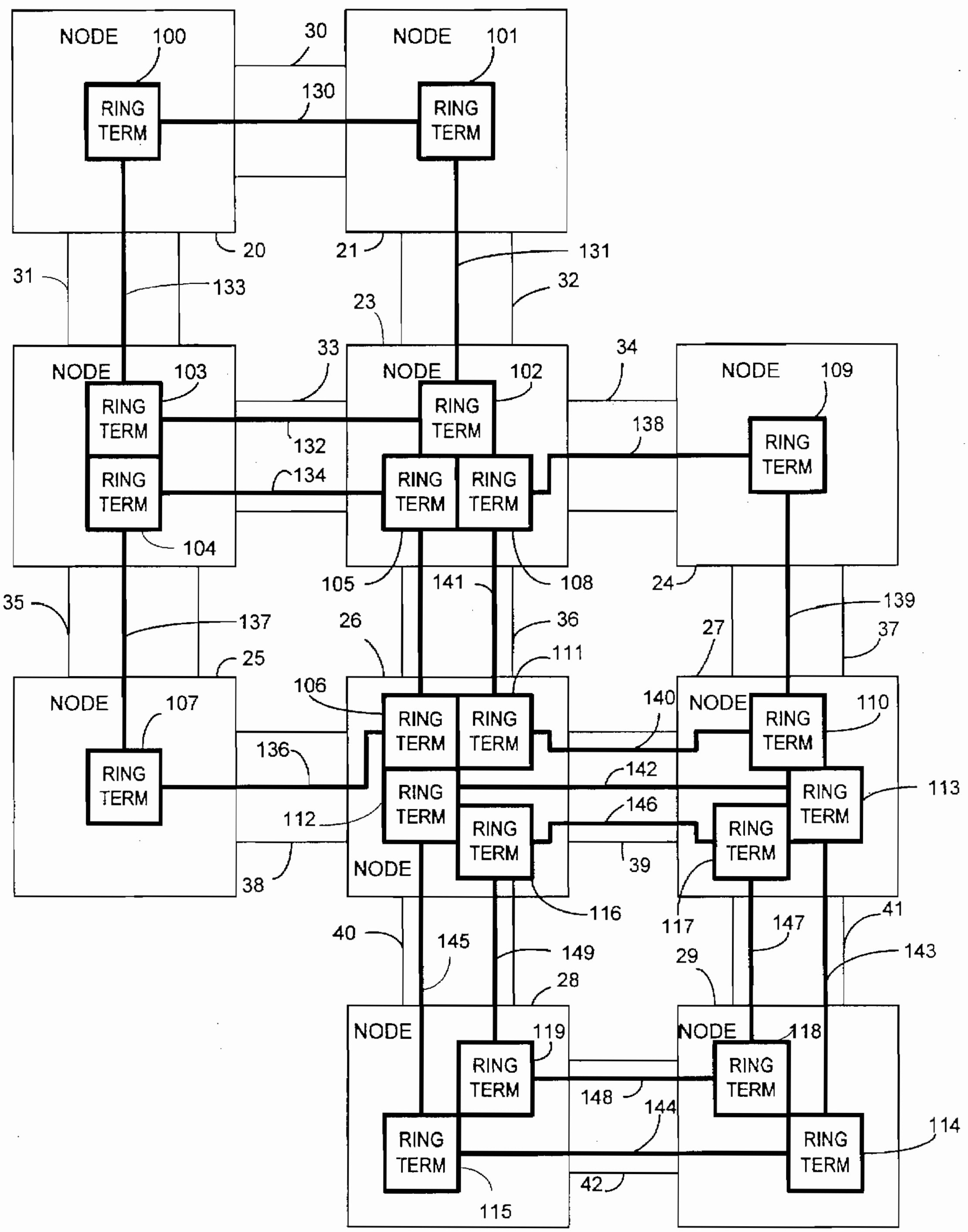
NODE
58
CROSS CONNECT
72
NODE
59
CROSS CONNECT

FIG. 2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NODE 102
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RING TERM
NODE 109
RING TERM
132
134
138
104
105
141
108
24
35
137
26
36
139
37
27
25
111
106
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RING TERM
38
NODE
39
116
117
41
40
145
147
149
143
28
29
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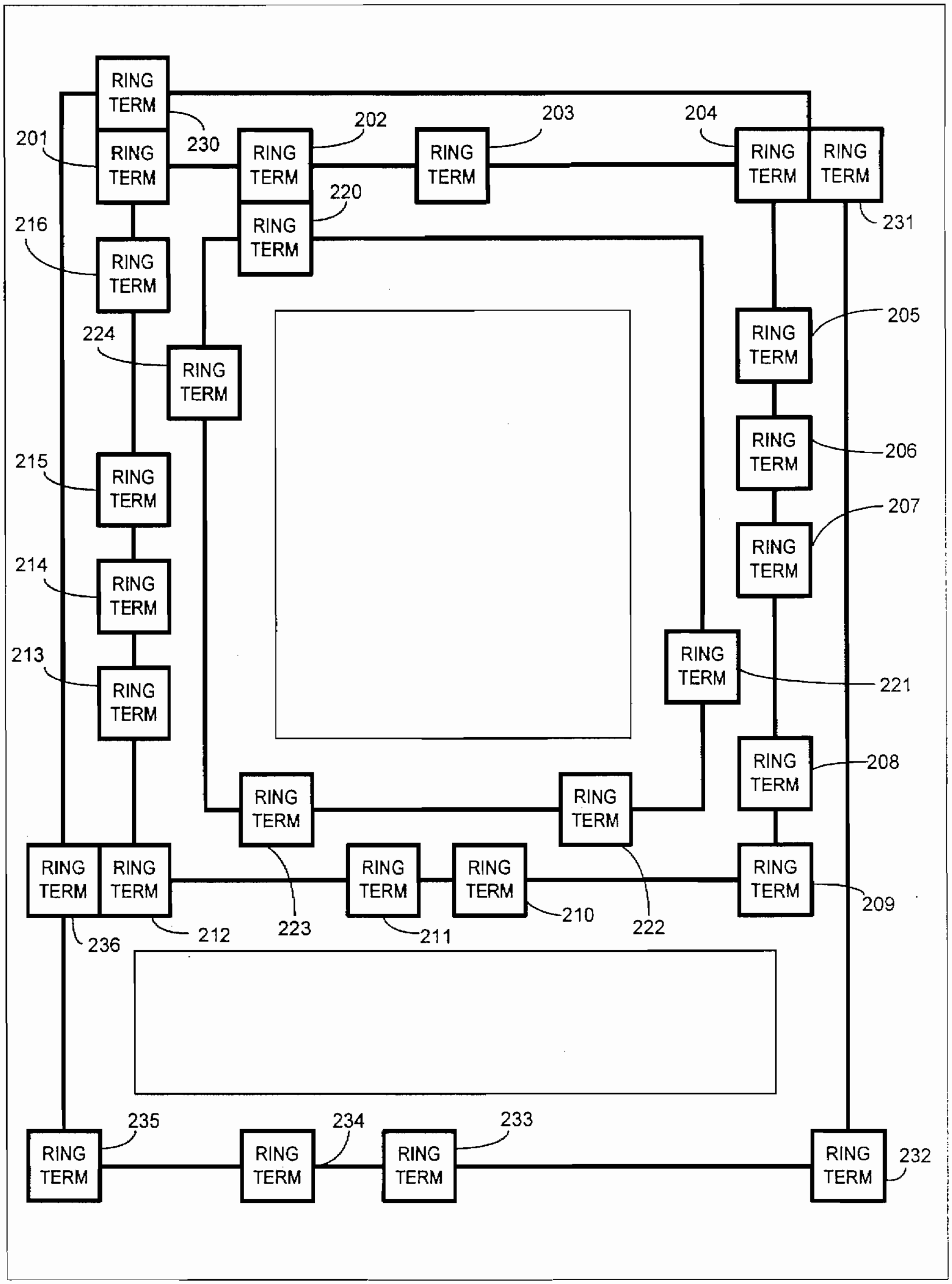
RING TERM
148
144
RING TERM
RING TERM
114
42
115

FIG. 3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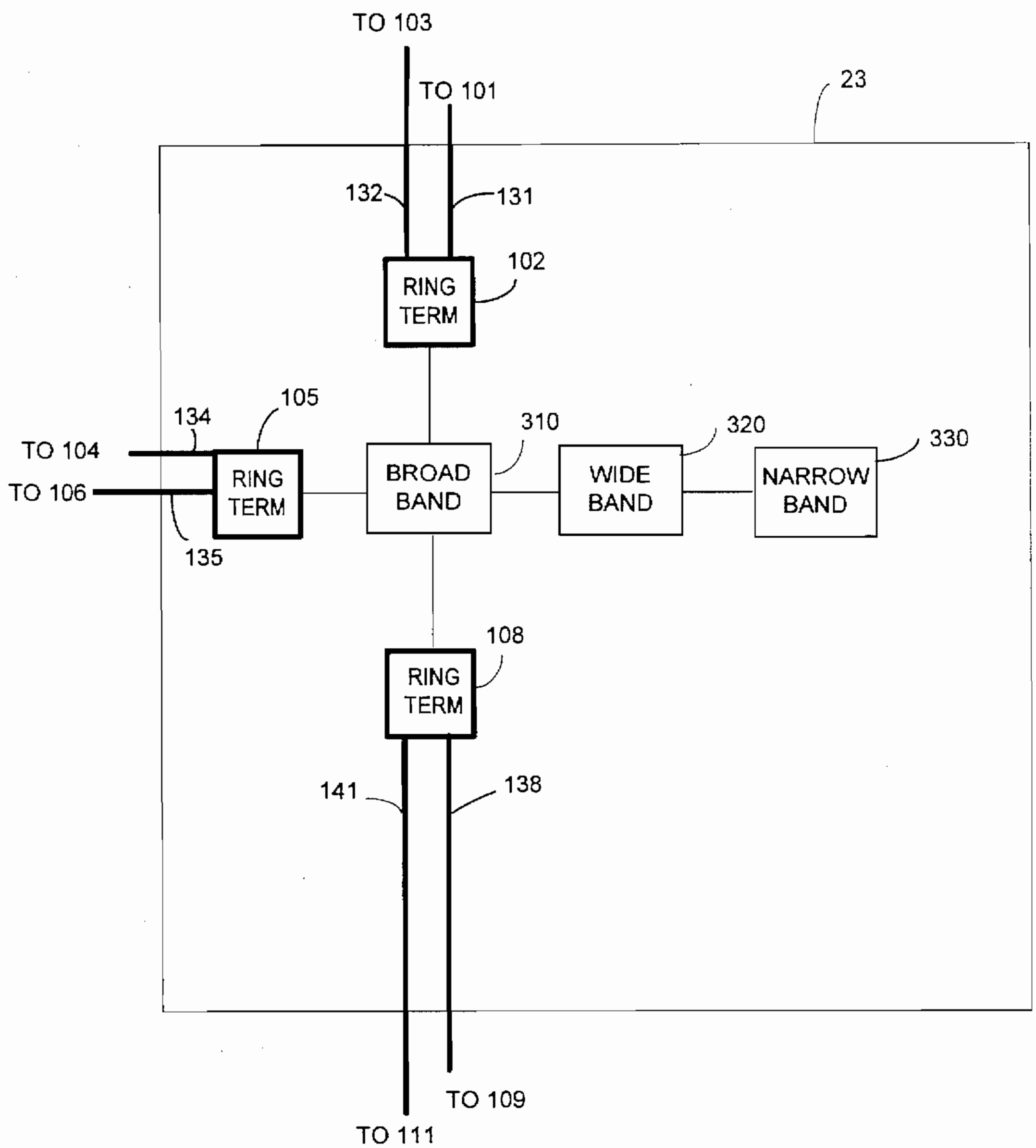
RING TERM

FIG. 4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TO 104
TO 106
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320
WIDE BAND
330
NARROW BAND
108
RING TERM
141
138
TO 109
TO 111

FIG. 5

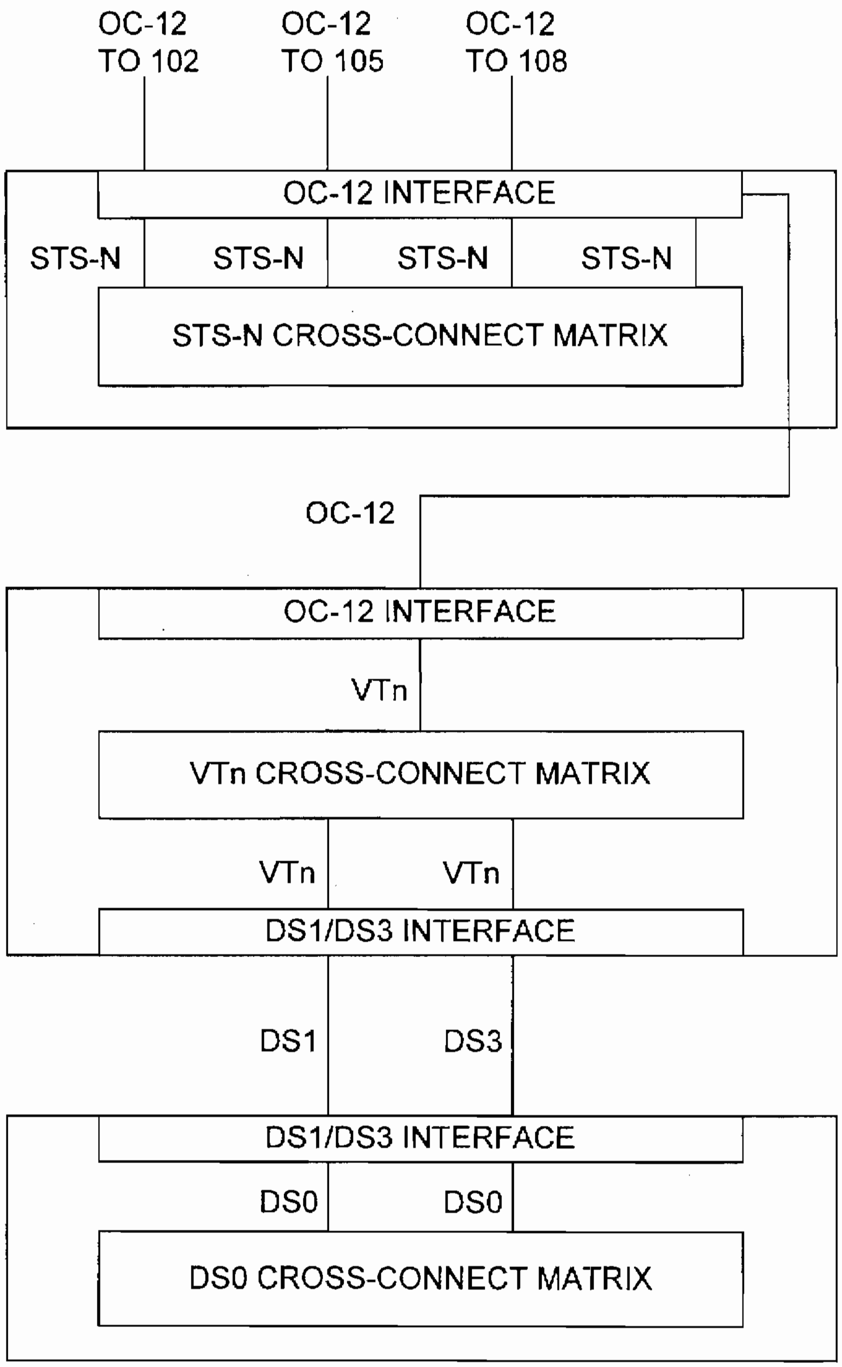
OC-12
TO 102
OC-12
TO 105
OC-12
TO 108
OC-12 INTERFACE
STS-N
STS-N
STS-N
STS-N
STS-N CROSS-CONNECT MATRIX
OC-12
OC-12 INTERFACE
VTn
VTn CROSS-CONNECT MATRIX
VTn
VTn
DS1/DS3 INTERFACE
DS1
DS3
DS1/DS3 INTERFACE
DS0
DS0
DS0 CROSS-CONNECT MATRIX

FIG. 6

SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE

BACKGROUND

1. Field of the Invention

The invention relates to synchronous optical networks (SONET) and specifically to the use of ring architectures that use stacked rings.

2. Description of the Prior Art

At present, proposed architectures for implementing SONET over relatively large geographic areas are Digital Cross-connect System (DCS) based. The relative size of these areas is larger than a Local Access and Transport Area (LATA), or larger than a metropolitan area. An example of such a network is an Interexchange Carrier IXC).

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed. Often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

The prior art DCS architecture for SONET deployment in a relatively large network is depicted in FIG. **2**. DCS architecture is well-known in the art and is based on point-to-point connections which employ cross-connect switching at the network nodes where point-to-point connections intersect. In FIG. **2**, nodes **20–29** and routes **30–42** are again shown as in FIG. **1**. In FIG. **2**, they are shown connected by DCS switches **50–59** over spans **60–72** occupying physical routes **30–42**. The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only 16 ring terminals.

In the large network environment, this standard puts a severe limitation on the number of ring terminals that may be placed on a ring. A large network, such an IXC, will require hundreds or even thousands of ring terminals to deploy SONET over the large geographic area covered by the network. These large geographic areas are greater than a LATA or a metropolitan area. At only 16 ring terminals per ring, the network is required to implement a high number of rings.

For the IXC deploying SONET, ring terminals will be required at all points of presence (POPs). A POP is where the IXC provides access to its network. Additionally, ring terminals are required at points where switching or grooming capability is located. An IXC network may cover thousands of square miles and contain thousands of POPs, switching, and grooming sites. This requires thousands of ring terminals. For an IXC to comply with SONET standards, the SONET architecture would include a very large number of

rings. This is because the thousands of POPs, switching, and grooming sites can only be connected at 16 ring terminals per ring.

The large number of rings coupled with the great geographic distances involved represent a costly amount of overbuild. This overbuild is caused by the fact that ring connections require return spans to complete the ring. The logical connections between ring terminals are called spans. These spans, in turn, require physical fiber routes to complete the ring. At present, a relatively large network is required to add an excessive amount of physical fiber routes to facilitate the high number of spans required to close the large number of rings. The rings must accommodate a large number of POPs, switching, and grooming sites.

In the local environment, this overbuild is not nearly as severe because the geographic areas are restricted within the LATA. As such, the use of ring architectures for SONET has been restricted to small geographic areas such LATAs and individual metropolitan areas. Additionally, networks may employ a single large ring which covers a large area because only one ring must be closed instead of the several rings implicated in large networks.

The large network using rings faces the problem of the extra spans required to close rings, the large number of rings, and the large geographic distances to span. These geographic distances comprise areas larger than a LATA or a metropolitan area. This problem is exacerbated by the constraint of using existing physical routes. If possible, the network tries to re-use its current physical routes in order to avoid having to acquire more physical space for its routes. Real estate costs, as well as, construction and equipment costs are a significant deterrent to acquiring new physical territory for spans. Additionally, due to the terrain problems on long routes, such as mountains, small rings may just not be possible.

The resulting inefficiency has driven the choice to use DCS architecture in the networks larger than LATAs or metropolitan areas. A DCS based network is point to point and requires no return connections. DCS architecture reduces the number of spans required to deploy SONET, and the spans required for DCS adapt well to the existing physical routes. As a result, DCS architecture is the choice at present for large network SONET architectures.

However, there are also problems caused by DCS architectures. DCS survivability is controlled by a centralized device called a Digital Cross-connect Management System (DCMS). The DCMS is well-known in the art. In FIG. **2**, DCMS **80** is shown and is connected to DCS switches **40–49** by signaling links **81**. When there is an interruption in a DCS network: 1) a DCS switch must sense the interruption, 2) the DCS switch must signal the DCMS of the condition, 3) the DCMS must determine alternate routing, 4) the DCMS must signal the alternate instructions to the DCS switches, and 5) the DCS switches must implement the alternate re-route instructions. At present, this sequence takes several minutes in a large network, such as an IXC. The several minute loss of service is a serious problem.

In contrast, rings may be self-healing. Self-healing SONET rings are detailed in ANSI Standard T1.105.XX Series. Survivability is achieved despite an interruption by routing traffic around the operational side of the ring to complete the connection. No communication with a central control device is needed. No complex re-route instructions need to be determined. This is one reason rings are the choice for networks covering small geographic areas. The small overbuild is offset by the improvement in survivability time. A network can restore service with self-healing rings in milliseconds.

At present, large networks implementing SONET face a dual problem. Ring architectures require grossly impractical overbuild for such a network in order to close the high number of large rings. These are rings which encompass areas larger than a LATA or metropolitan area. The problem is due in part to the SONET standards, the large number of network nodes, and the length of existing physical routes. Although DCS architectures relieve the overbuild problem, the survivability of a DCS based network takes several minutes for a large network. This amount of time is unacceptable. For the above reasons, relatively large networks need a SONET system that does not require impractical overbuild, yet also has millisecond survivability.

SUMMARY

The present invention is a SONET system that satisfies the need of a large network architecture that efficiently complies with the SONET standards and offers acceptable survivability. The SONET system includes SONET ring terminals which are connected by SONET spans to form a ring architecture. The ring architecture does not allow the rings to share ring terminals. Some of the rings individually encompass relatively large geographic areas. These geographic areas are larger than a LATA or a metropolitan area. Particular ring terminals on different rings are connected to provide interconnectivity among the rings. This connection may be a DCS connection. The rings are also self-healing. Self-healing rings provide excellent survivability in a large network. The logical spans of different rings can be stacked within the same physical route in order to limit the number of ring terminals per ring.

The present invention overcomes the problem of implementing a SONET system over a large geographic area by stacking rings. Stacked rings have logical spans that occupy the same physical routes. This allows the rings to be restricted to less than 16 ring terminals per ring, yet still enables the system to accommodate the numerous ring terminals required on the physical routes of a large network. By separating logical spans within the same physical route, inefficient overbuild inherent with large rings is avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a diagram depicting network nodes and physical routes without showing network connections.

FIG. **2** is a diagram depicting the prior art system using a DCS based architecture.

FIG. **3** is a diagram of a version of the present invention depicting a ring architecture.

FIG. **4** is a diagram of a version of the present invention depicting stacked rings.

FIG. **5** is a diagram of a version of the present invention depicting a DCS connection.

FIG. **6** is a diagram of a version of the present invention depicting a DCS connection.

DESCRIPTION

The present invention is a SONET system for a relatively large network that uses self-healing rings. These relatively large areas are larger than a LATA or metropolitan area. An example of such a network is an IXC. An additional feature of the invention is that the rings may be stacked. The rings are created by connecting SONET ring terminals with SONET spans and are designed to be self-healing. The ring terminals of different rings are connected to each other to provide interconnectivity among the rings. This connection may be based on DCS equipment. SONET is discussed in the SONET Sprint Technical Report of March 1993.

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed. Often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

FIG. **2** illustrates how the nodes **20–29** would be connected over routes **30–42** in a Digital Cross-connect System (DCS) based architecture. FIG. **2** is provided for comparative purposes. DCS connections are point-to-point. They form a grid with DCS switches **50–59** at the intersection points of spans **60–72** which occupy physical routes **30–42**. Each DCS switch is capable of switching traffic in any direction, as well as, adding and dropping traffic. These add/drop connections are not shown. The control over the switching is provided by Digital Cross-connect Management System (DCMS) **80**. Signalling links **81** is shown between the DCS switches **50–59** and the centralized DCMS **80**.

The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only 16 ring terminals. When a large network deploys a new architecture, it is highly desirable to reuse the existing node sites and physical routes as much as possible due to the costs of land, equipment, and construction. These conditions cause the problems discussed in the background section above.

FIG. **3** shows a version of the present invention. Nodes **20–29** are again shown as a part of the network. SONET ring terminals **100–119** are located at the nodes. Ring terminals **100–119** are comprised of SONET add/drop muxes (ADMs) which are well known in the art. Examples of ADMs are the Alcatel Models 1648SM, 1624SM, and 1612SM which respectively operate at 0C-48, OC-24, and OC-12. Each ring terminal is capable of receiving, switching, and transmitting SONET traffic on the connected SONET spans. The ring terminal can add or drop traffic from the SONET rings. These add/drop connections are not shown. The ring terminals also provide grooming for the SONET traffic. These ring terminal capabilities and many others are well known in the art.

SONET spans **130–149** connect the ring terminals. Spans represent logical connections. The operation of SONET transmission using ADMs connected by fiber spans is well known in the art. These spans are logical connections which occupy physical routes, such as optical fibers. Four fiber unidirectional lines are preferred for each span. Other types of fiber lines are known, such as two and four fiber bidirectional or two fiber unidirectional, and even single fiber lines can be used. Dispersion shifted fiber is preferred, but other fiber, such as standard single mode fiber can be used.

In the present invention, the spans interconnect particular ring terminals over physical routes to form rings. As shown in FIG. **3**, ring terminals **100–103** are connected by spans **130–133** to form a ring. Other rings are formed by ring terminals **104–107**, **108–111**, **112–115**, and **116–119** which are connected respectively by spans **134–137**, **138–141**, **142–145**, and **146–149**.

Spans or groups of spans follow physical routes. These physical routes are typically comprised of optical fibers. The spans represent logical connections within the physical route. On FIG. **3**, the same physical routes from FIGS. **1** and **2** are used. As such, route **30** contains span **130**. The following is a list of route—span combinations for FIG. **3**: route **30**—span **130**, route **31**—span **133**, route **32**—span **131**, route **33**—spans **132** and **134**, route **34**—span **138**, route **35**—span **137**, route **36**—spans **135** and **141**, route **37**—span **139**, route **38**—span **136**, route **39**—spans **140** and **142** and **146**, route **40**—spans **145** and **149**, route **41**—**143** and **147**, and route **42**—spans **144** and **148**.

As stated above, in order to comply with ANSI T1.105.XX Series, each ring is restricted to a maximum of 16 ring terminals. Typically, the network will place more ring terminals on each ring than are shown on FIG. **3**, but a smaller number was used for clarity. As a practical matter, each POP, switching, and/or grooming site may require a ring terminal.

When more than 16 ring terminals are encountered, a second ring must be used. In the present invention, the second ring is stacked within the physical route of the first ring in this situation. Rings may be stacked whether or not the 16 ring terminal limit has been reached. Stacked rings maintain separate ring terminals. In FIG. **3**, the ring formed by ring terminals **112–115** is stacked on the ring formed by ring terminals **116–119**, but the rings share the same physical routes. In that way, the number of ring terminals on a physical route can be increased without increasing the number of ring terminals per ring.

For example, in the above discussed stacked rings (ring terminals **112–119**), the total number of ring terminals on the physical route is eight, but the number of ring terminals per ring is four. By stacking more rings within the physical route, the ring terminal per ring ratio can be maintained at four, but the total number of ring terminals on the physical route can be increased.

FIG. **4** shows a series of stacked rings. One ring is formed by connecting ring terminals **201–216** with SONET spans. This ring has the maximum 16 ring terminals allowed by the standards. When ring terminals **220–224** are added to the network, a second ring must be added to remain in compliance with the SONET standard. For example, take the existing physical route containing the spans that form a ring with ring terminals **201–216**. If new POPs are added along this route, more than the maximum number of 16 ring terminals are required. Thus, new ring terminals **220–224** which service the new POPs must be added to a second ring stacked on the first ring. Stacked rings do not need to be mirror images of one another. The ring formed by ring terminals **230–237** shares only some of the physical route of the other two rings and is only partially stacked. A community of interest ring may share a portion of the physical routes of several rings.

In the preferred embodiment, each span which connects two ring terminals occupies a four fiber unidirectional line. However, spans may occupy other types of lines. Spans may also share the same actual fiber between pairs of ring terminals which are still on different rings. In this case, SONET transmission on the rings is separated on the fiber by using optical couplers or wave division multiplexing (WDM). Optical couplers and WDM are well known in the art. Different rings still may not share ring terminals.

For example, in FIG. **3** ring terminals **103** and **104** are both located at node **22**. Ring terminals **102** and **105** are both located at node **23**. Ring terminals **102** and **103** are on a ring connected by span **132** over route **33**. Ring terminals **104** and **105** are on a different ring connected by span **134** over route **33**. Both spans **132** and **134** may occupy the same actual fiber in route **33** by using optical couplers or WDM to separate the rings on the same fiber. As stated, in the preferred embodiment, spans **132** and **134** would each occupy its own four fiber unidirectional line.

This stacking technique can be used to alleviate the amount of fiber required. By allowing different spans to share fiber, new rings may be added to a fiber route to accommodate new ring terminals. Thus by stacking rings within a fiber route, the amount of fiber overbuild required to close rings can be controlled. Preferably, working and protect lines are not placed within the same fiber.

In the present invention, particular ring terminals on different rings will be connected to allow transmission from ring to ring. This connection is preferably a DCS connection, but other connections are possible. Nodes at which different rings are connected are called hubs. Typically, ring terminals at the same node are all on different rings and would be interconnected with a connection to form a hub. For example on FIG. **3**, ring terminals **110**, **113**, and **117** at node **27** would be interconnected. Although the ring terminals at a node do not have to be connected, all ring terminals at the same node preferably are connected. This connection allows the ring terminals on different rings to be connected while maintaining the 16 ring terminals per ring restriction.

A DCS connection is shown in FIG. **5**. Node **23** connects different rings and includes ring terminals **102**, **105**, and **108**. These ring terminals are connected to other ring terminals at different nodes by spans **131**, **132**, **134**, **135**, **138**, and **141** respectively as shown on FIG. **3**. The add/drop connections of the ring terminals are not shown. On FIG. **5**, ring terminals **102**, **105**, and **108** are interconnected using DCS connections. The DCS connection is comprised of a DCS device or devices with the capability to interface, groom, and switch SONET traffic between ring terminals. The DCS connection can also offer local access.

In the preferred embodiment, this DCS connection is comprised of three connected devices, broadband DCS **310**, wideband DCS **320**, and narrowband DCS **330**. Those skilled in the art appreciate that the capabilities of these devices could be housed in one device or distributed among multiple devices.

Broadband DCS **310** is connected to ring terminals **102**, **105**, **108**, and wideband DCS **320** by standard fiber connections which are preferably four fiber unidirectional lines operating at OC-12. Broadband DCS **310** transmits traffic between the ring terminals. It is designed to handle traffic at or above the DS3 level, and to divert traffic below DS3 to the wideband DCS **320**.

One version of a DCS connection is shown in FIG. **6**. Broadband DCS **310** is shown. An example of broadband

DCS **310** is the Alcatel Model 1633SX. Broadband DCS **310** accepts OC-12 lines from the ring terminals. Although only three ring terminals are connected to broadband DCS **310**, more ring terminals may be connected. These OC-12 lines are connected to interface **312**. Interface **312** breaks down each OC-12 signal into component STS signals. These signals are in turn, connected to cross-connect matrix **314** for grooming. This matrix accepts signals at the STS level or higher, and is capable of establishing a connection from any STS to any other STS using time slot interchange. Typically, these connections are pre-determined and programmed into broadband DCS **310**. Although not shown, broadband DCS **310** could accept local access signals into an interface convert these signals into STS signals, and connect them to cross-connect matrix **314** for grooming. As such, broadband DCS **310** could accept SONET signals from both the rings and local sources and connect them.

Wideband DCS **320** is shown. An example of wideband DCS **320** is the Tellabs Model 5500. Wideband DCS **320** accepts the **0C-12** signal from broadband DCS **310** into interface **322**. These signals are broken down into component VT signals and connected to cross-connect matrix **324** which has the capability to connect any VT to any other VT. Although not shown, local access could also be accepted in a similar manner. Interface **326** accepts a DS1 and a DS3 connection from narrowband DCS **330**. Interface **326** maps and grooms these signals into VT signals and connects them to cross-connect matrix **324**.

Narrowband DCS **330** is shown. An example of the narrowband DCS is the Digital Switch Corporation Model CS-1L. It accepts the DS1 and DS3 signals from wideband DCS **320** into interface **332**. These signals are converted into DS**0** signals and connected to cross-connect matrix **334** which has the capability to connect any DS**0** to any other DS**0**. Local access can also be accepted.

Although, the preferred signal levels for interface, grooming, and cross-connection are listed above, those skilled in the art are aware that other choices would be operational. The present invention is not restricted to these listed levels, but they are given as preferred and operational levels. The DCS connection provided by these devices is capable of processing signals transmitted between rings. This processing may occur at different signal levels. The DCS connection also provides local access. In this way, connectivity is provided between the ring terminals of different rings, and to local sources. The DCS connection formed may be any device or combination of devices with the above capabilities. For purposes of redundancy, additional back-up DCS connection capability can be added at a node.

Other connections are also operational in the context of the present invention. In one embodiment, direct cabling at OC-N or STS-N could be used to connect ring terminals on different rings. In another embodiment, an ATM switch with the DCS functionality described could be used to connect the ring terminals of different rings.

At present, SONET standards are driving the choice of OC-12 transmission. This causes a problem since there are no devices currently available that accept, groom, and connect OC-12 traffic between SONET rings. This is another reason that networks have opted for a DCS based architecture. The DCS architecture does not require an OC-12 interface between rings which is currently unavailable. The present invention solves the problem of ring connectivity at OC-12 with the DCS connection.

As stated above, ring architectures solve the problem of excessive survivability time because they can be designed to be self-healing. At present, the benefit of self-healing rings is outweighed in the large network environment because of the impractical overbuild and connectivity problems. However, by stacking rings, and using a DCS connection between rings, the present invention overcomes these problems. As a result, self-healing ring technology can be employed in the present invention to provide significantly improved survivability features.

There are three basic types of self-healing ring methods: path switched unidirectional, line switched two fiber bidirectional, and line switched four fiber bidirectional. Line switched four fiber bidirectional is preferred. These formats for self-healing rings are known in the art, but they have yet to be applied within the large network environment because of the above stated problems with rings in networks larger than LATAs or metropolitan areas. The present invention employs self-healing capability in particular ring terminals on each ring. Problems are avoided by routing the traffic around the operational side of the ring to the destination.

As a result, the present invention provides a SONET system that employs self-healing rings which can efficiently span large geographic distances. Although it is preferred to minimize the size of rings, large rings are inherent to the large network environment. An IXC is an example of a large network, but in the present invention, a network which encompasses an area larger than a LATA or a metropolitan area is considered a relatively large network. Traffic can thus be transmitted from LATA to LATA, or metropolitan area to metropolitan area and maintain millisecond survivability. Current DCS based SONET architectures cannot provide this performance in the large network environment. Current SONET ring architectures are restricted to use in small geographic areas, such as LATAs and metropolitan areas, or to single large rings. By featuring stacked self-healing SONET rings with DCS connections, the present invention eliminates these current problems.

What is claimed is:

1. A SONET system which comprises:

(a) a plurality of SONET ring terminals;

(b) a plurality of SONET spans connecting the ring terminals to form an architecture comprising a plurality of rings wherein each ring is comprised of unique ring terminals and spans and is not comprised of any ring terminals and spans of another ring, and wherein particular spans of different rings are stacked within a single fiber route; and

(c) a plurality of connections between the rings that are operational to provide interconnectivity among the rings.

2. A SONET system which comprises:

(a) a plurality of SONET ring terminals;

(b) a plurality of SONET spans connecting the ring terminals to form an architecture comprising a plurality of rings wherein each ring is comprised of unique ring terminals and spans and is not comprised of any ring terminals and spans of another ring, wherein a plurality of the rings individually encompass geographic areas that are large than a LATA, and wherein particular spans of different rings are stacked within a single physical route; and

(c) a plurality of connections between the rings that are operational to provide interconnectivity among the rings.

3. The SONET system of claim **2** wherein the connections between the rings are Digital Cross-connect System (DCS) connections.

4. The SONET system of claim **3** wherein the DCS connections each comprise a broadband DCS, a wideband DCS, and a narrowband DCS.

5. The SONET system of claim **2** wherein the connections between the rings each comprise at least one ATM switch.

6. The SONET system of claim **2** wherein the connections between the rings are comprised of direct cabling.

7. The SONET system of claim **2** wherein the connections between the rings accept traffic from the ring terminals at OC-12.

8. The SONET system of claim **2** wherein the SONET system forms at least a portion of an Interexchange Carrier (IXC) network.

9. The SONET system of claim **2** wherein the rings are restricted to 16 ring terminals per ring.

10. The SONET system of claim **2** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using wave division multiplexing.

11. The SONET system of claim **2** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using optical couplers.

12. The SONET system of claim **2** wherein a plurality of the spans occupy four fiber unidirectional lines.

13. The SONET system of claim **2** wherein the rings are self-healing rings.

14. A SONET system which comprises:

(a) a plurality of SONET ring terminals;

(b) a plurality of SONET spans connecting the ring terminals to form an architecture comprising a plurality of rings wherein each ring is comprised of unique ring terminals and spans and is not comprised of any ring terminals and spans of another ring, wherein a plurality of the rings individually encompass geographic areas that are larger than a metropolitan area, and wherein particular spans of different rings are stacked within a single physical route; and

(c) a plurality of connections between the rings that are operational to provide interconnectivity among the rings.

15. The SONET system of claim **14** wherein the connections between the rings are Digital Cross-connect System (DCS) connections.

16. The SONET system of claim **15** wherein the DCS connections each comprise a broadband DCS, a wideband DCS, and a narrowband DCS.

17. The SONET system of claim **14** wherein the connections between the rings each comprise at least one ATM switch.

18. The SONET system of claim **14** wherein the connections between the rings are comprised of direct cabling.

19. The SONET system of claim **14** wherein the connections between the rings accept traffic from the ring terminals at OC-12.

20. The SONET system of claim **14** wherein the SONET system forms at least a portion of an Interexchange Carrier (IXC) network.

21. The SONET system of claim **14** wherein the rings are restricted to 16 ring terminals per ring.

22. The SONET system of claim **14** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using wave division multiplexing.

23. The SONET system of claim **14** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using optical couplers.

24. The SONET system of claim **14** wherein a plurality of the spans occupy four fiber unidirectional lines.

25. The SONET system of claim **14** wherein the rings are self-healing rings.

26. A SONET system which comprises:

(a) a plurality of SONET ring terminals;

(b) a plurality of SONET spans connecting the ring terminals to form an architecture comprising a plurality of rings wherein each ring is comprised of unique ring terminals and spans and is not comprised of any ring terminals and spans of another ring, wherein a plurality of the rings individually encompass geographic areas that are operational to connect two non-adjacent LATAs on a single ring, and wherein particular spans of different rings are stacked within a single physical route; and

(c) a plurality of connections between the rings that are operational to provide interconnectivity among the rings.

27. The SONET system of claim **26** wherein the connections between the rings are Digital Cross-connect System (DCS) connections.

28. The SONET system of claim **27** wherein the DCS connections each comprise a broadband DCS, a wideband DCS, and a narrowband DCS.

29. The SONET system of claim **26** wherein the connections between the rings each comprise at least one ATM switch.

30. The SONET system of claim **26** wherein the connections between the rings are comprised of direct cabling.

31. The SONET system of claim **26** wherein the connections between the rings accept traffic from the ring terminals at OC-12.

32. The SONET system of claim **26** wherein the SONET system forms at least a portion of an Interexchange Carrier (IXC) network.

33. The SONET system of claim **26** wherein the rings are restricted to 16 ring terminals per ring.

34. The SONET system of claim **26** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using wave division multiplexing.

35. The SONET system of claim **26** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using optical couplers.

36. The SONET system of claim **26** wherein a plurality of the spans occupy four fiber unidirectional lines.

37. The SONET system of claim **26** wherein the rings are self-healing rings.

38. A SONET system which comprises:

(a) a plurality of SONET ring terminals;

(b) a plurality of SONET spans connecting the ring terminals to form an architecture comprising a plurality of rings wherein each ring is comprised of unique ring terminals and spans and is not comprised of any ring terminals and spans of another ring, wherein a plurality of the rings individually encompass geographic areas that are operational to connect two metropolitan areas on a single ring, and wherein particular spans of different rings are stacked within a single physical route; and

(c) a plurality of connections between the rings that are operational to provide interconnectivity among the rings.

39. The SONET system of claim **38** wherein the connections between the rings are Digital Cross-connect System (DCS) connections.

40. The SONET system of claim **39** wherein the DCS connections each comprise a broadband DCS, a wideband DCS, and a narrowband DCS.

41. The SONET system of claim **38** wherein the connections between the rings each comprise at least one ATM switch.

42. The SONET system of claim **38** wherein the connections between the rings are comprised of direct cabling.

43. The SONET system of claim **38** wherein the connections between the rings accept traffic from the ring terminals at OC-12.

44. The SONET system of claim **38** wherein the SONET system forms at least a portion of an Interexchange Carrier (IXC) network.

45. The SONET system of claim **38** wherein the rings are restricted to 16 ring terminals per ring.

46. The SONET system of claim **38** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using wave division multiplexing.

47. The SONET system of claim **38** wherein a plurality of the particular spans of different rings are stacked within a single fiber route using optical couplers.

48. The SONET system of claim **38** wherein a plurality of the spans occupy four fiber unidirectional lines.

49. The SONET system of claim **38** wherein the rings are self-healing rings.

* * * * *

EXHIBIT B

US006108339A

United States Patent [19]

Norman, Jr.

[11] **Patent Number: 6,108,339**

[45] **Date of Patent: *Aug. 22, 2000**

[54] **SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE**

[75] Inventor: **Charles William Norman, Jr.,** Overland Park, Kans.

[73] Assignee: **Sprint Communications Company, L. P.,** Kansas City, Mo.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/974,774**

[22] Filed: **Nov. 20, 1997**

Related U.S. Application Data

[63] Continuation of application No. 08/203,165, Feb. 28, 1994, Pat. No. 5,742,605.

[51] **Int. Cl.**[7] **H04L 12/28**; H04L 12/56

[52] **U.S. Cl.** **370/405**

[58] **Field of Search** 370/352, 351, 370/353–356, 386, 388, 468, 401–406, 535, 539

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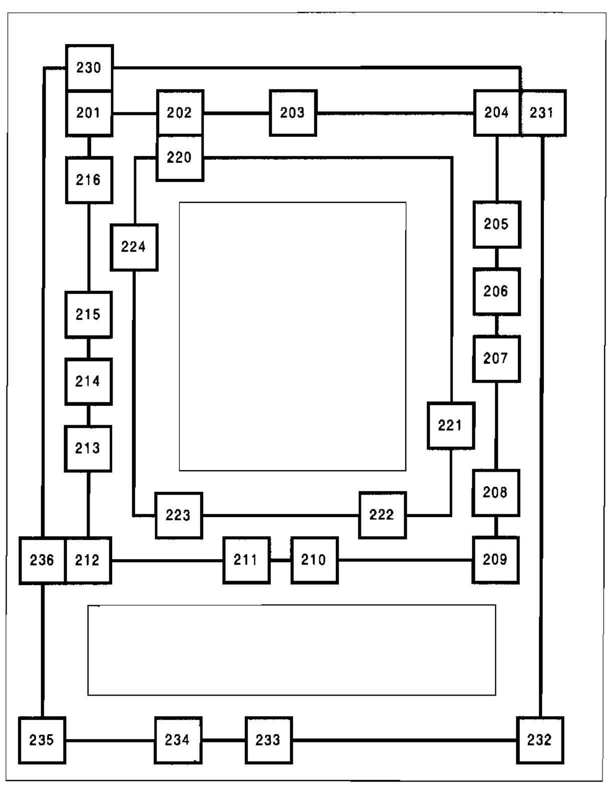
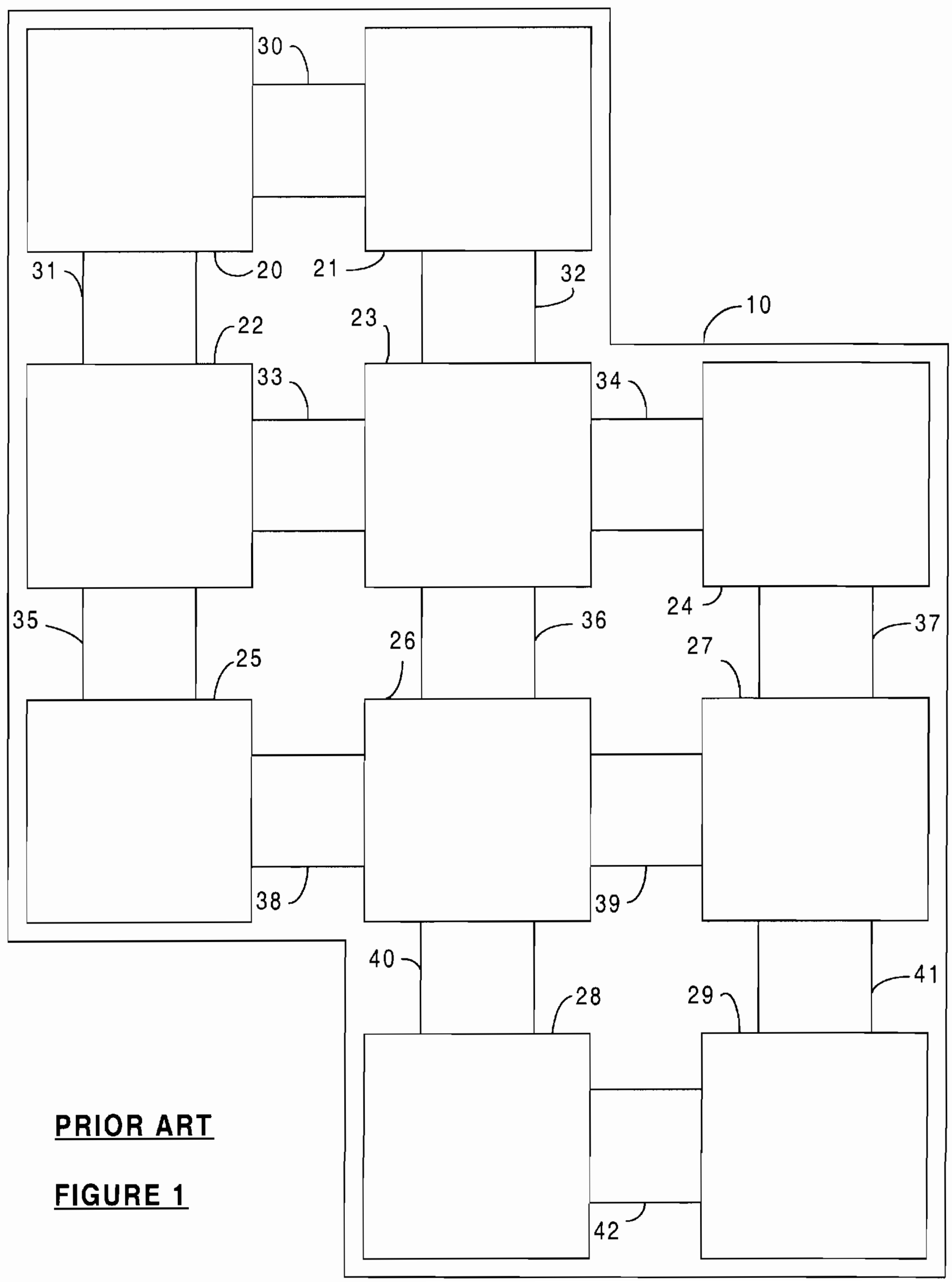
Primary Examiner—Ajit Patel
Attorney, Agent, or Firm—Harley R. Ball

[57] **ABSTRACT**

The present invention is a SONET system for use in large geographic areas, such as areas encompassed by an IXC network, or which are larger than a LATA or a metropolitan area. The system uses self-healing rings which are interconnected. Some of the rings are stacked within the same physical routes in order to minimize the number of ring terminals on each ring.

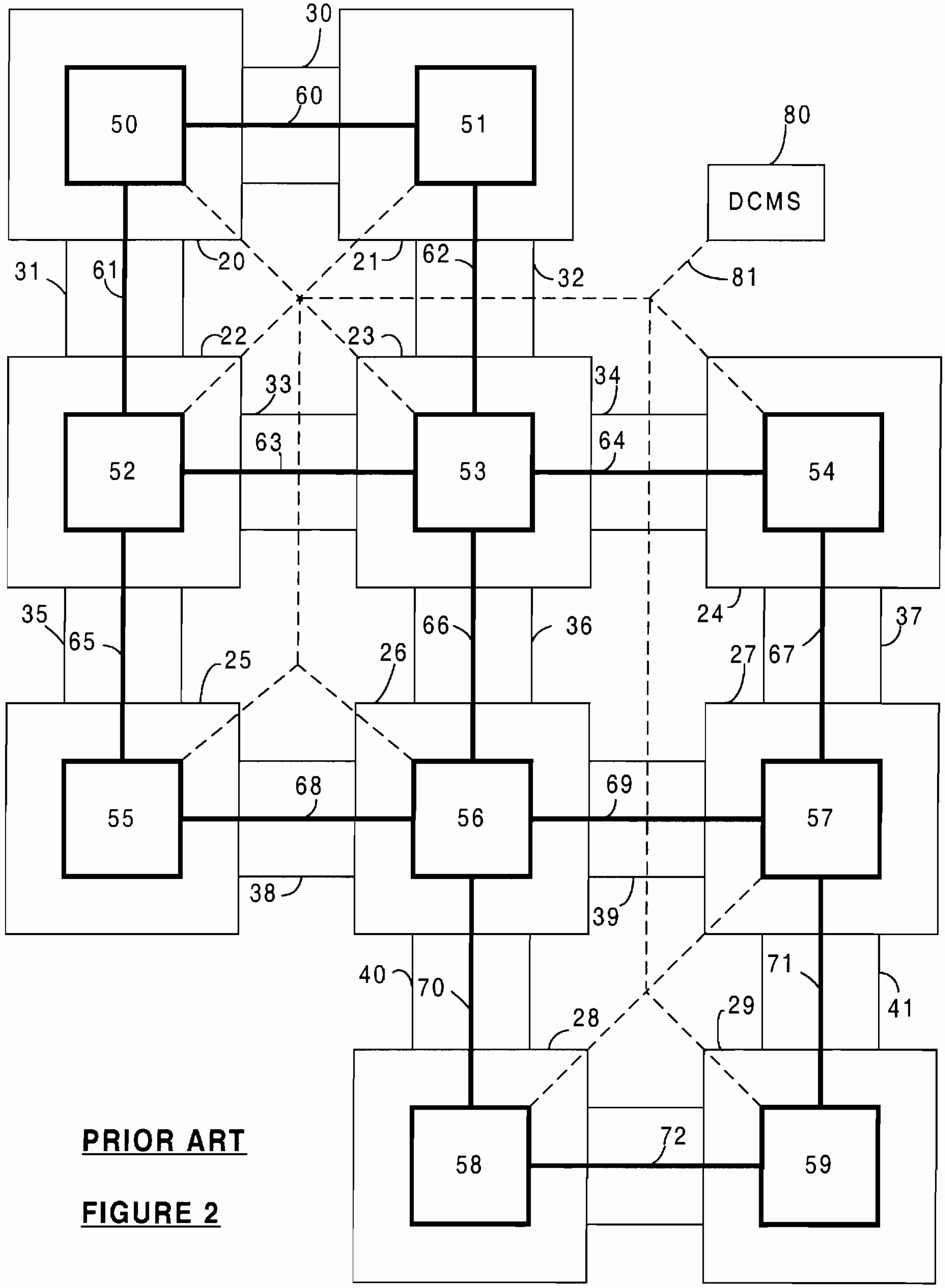
26 Claims, 6 Drawing Sheets





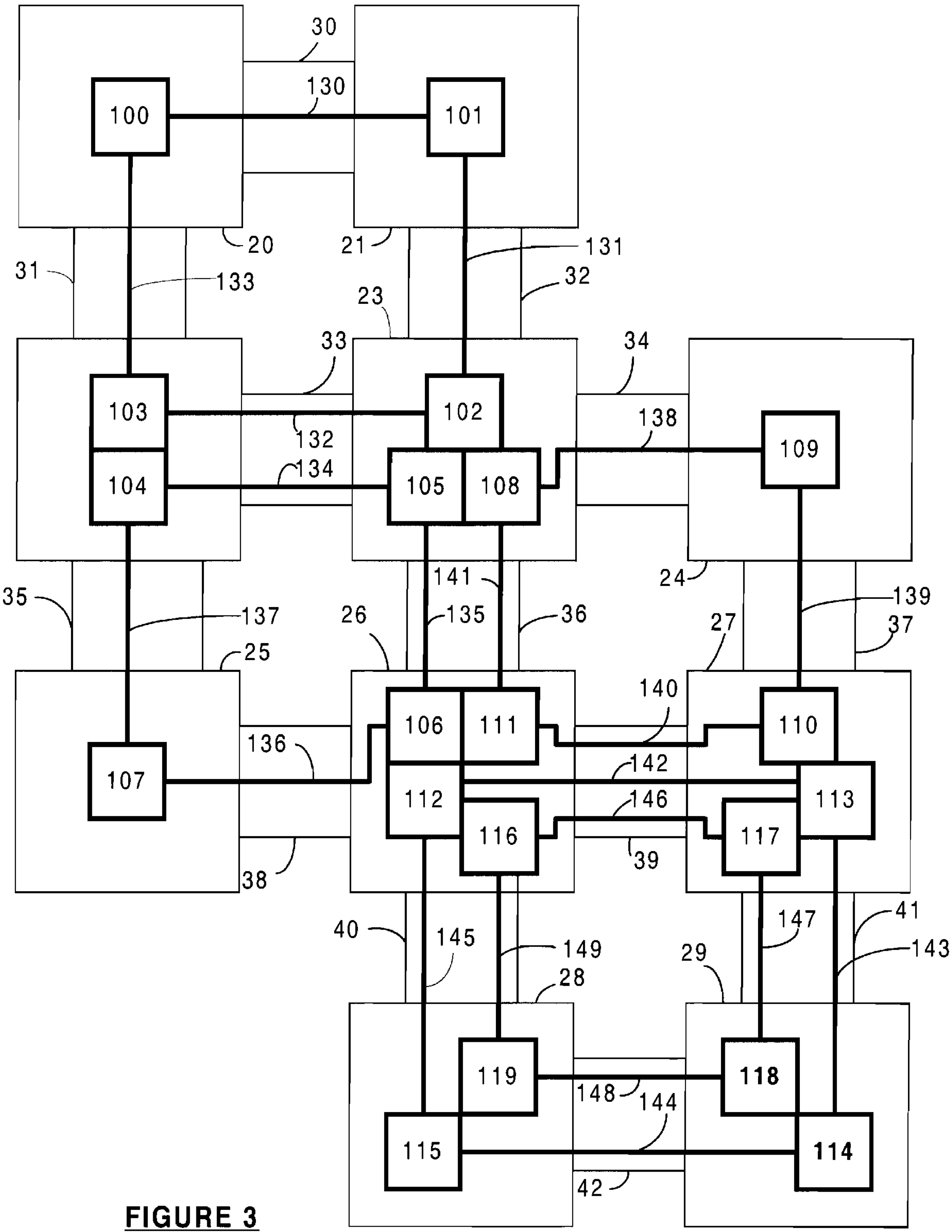
PRIOR ART

FIGURE 1



PRIOR ART

FIGURE 2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144
115
114
42

FIGURE 3

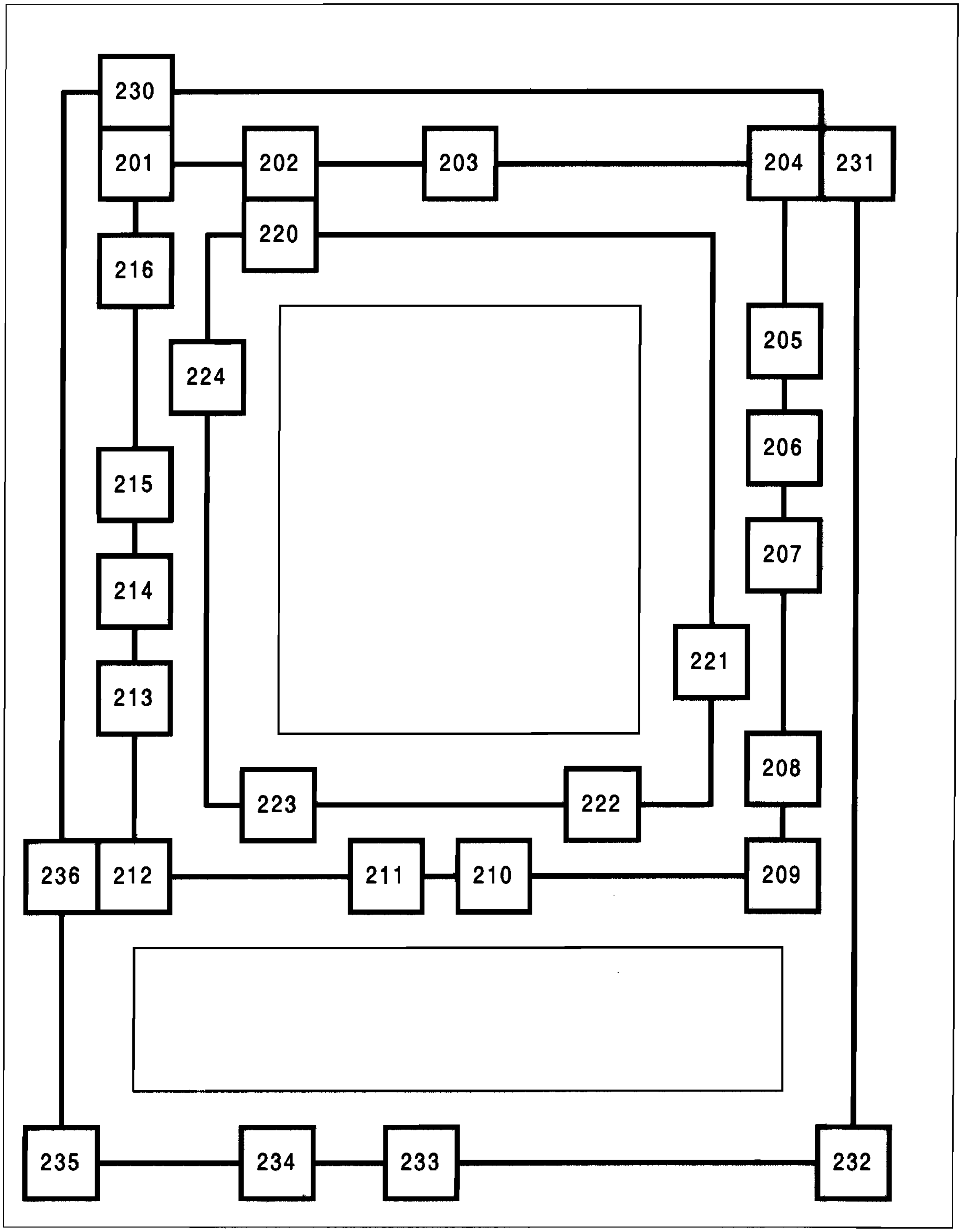

230
201
202
203
204
231
220
216
224
205
206
215
214
207
221
213
208
223
222
236
212
211
210
209
235
234
233
232

FIGURE 4

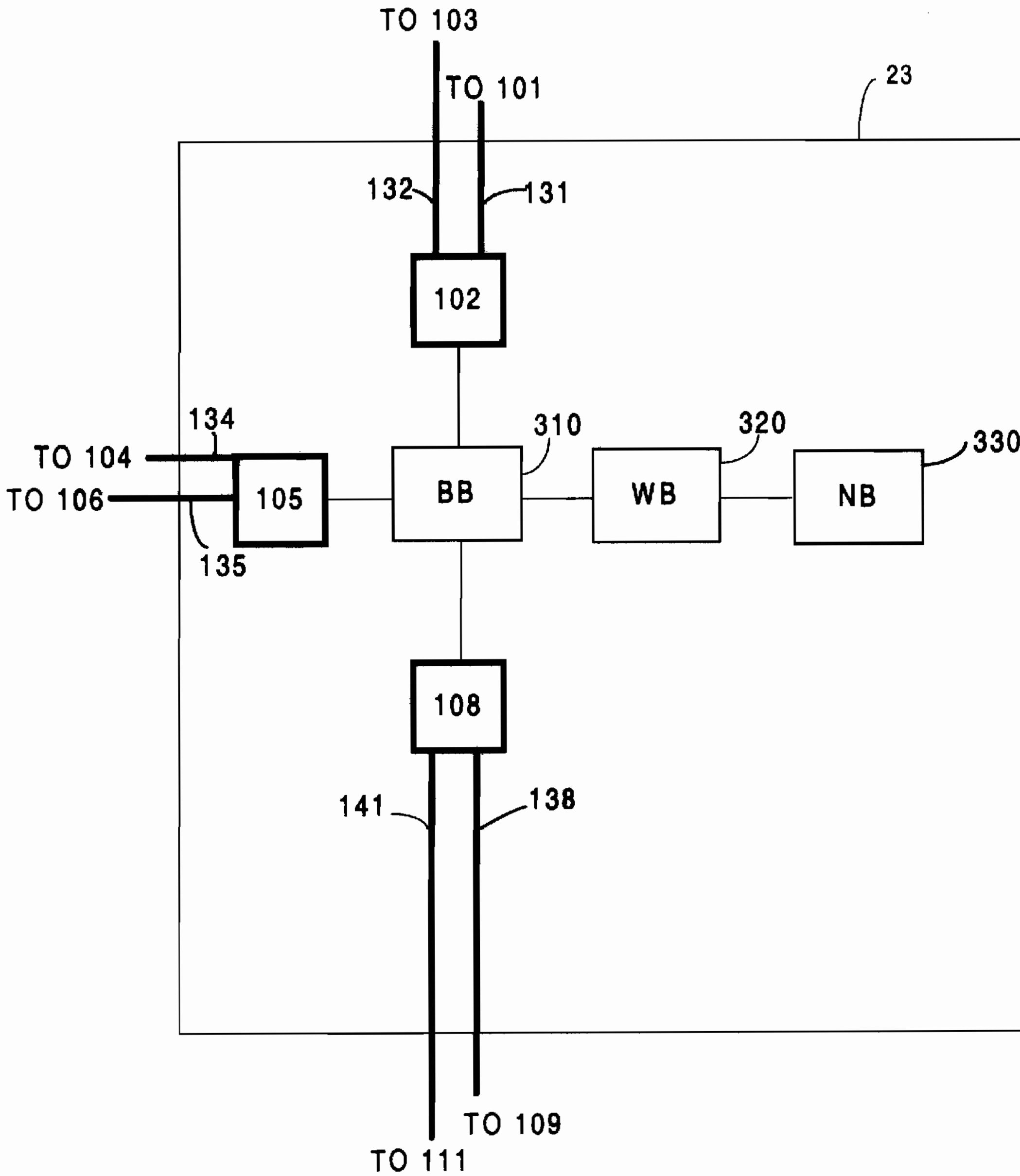
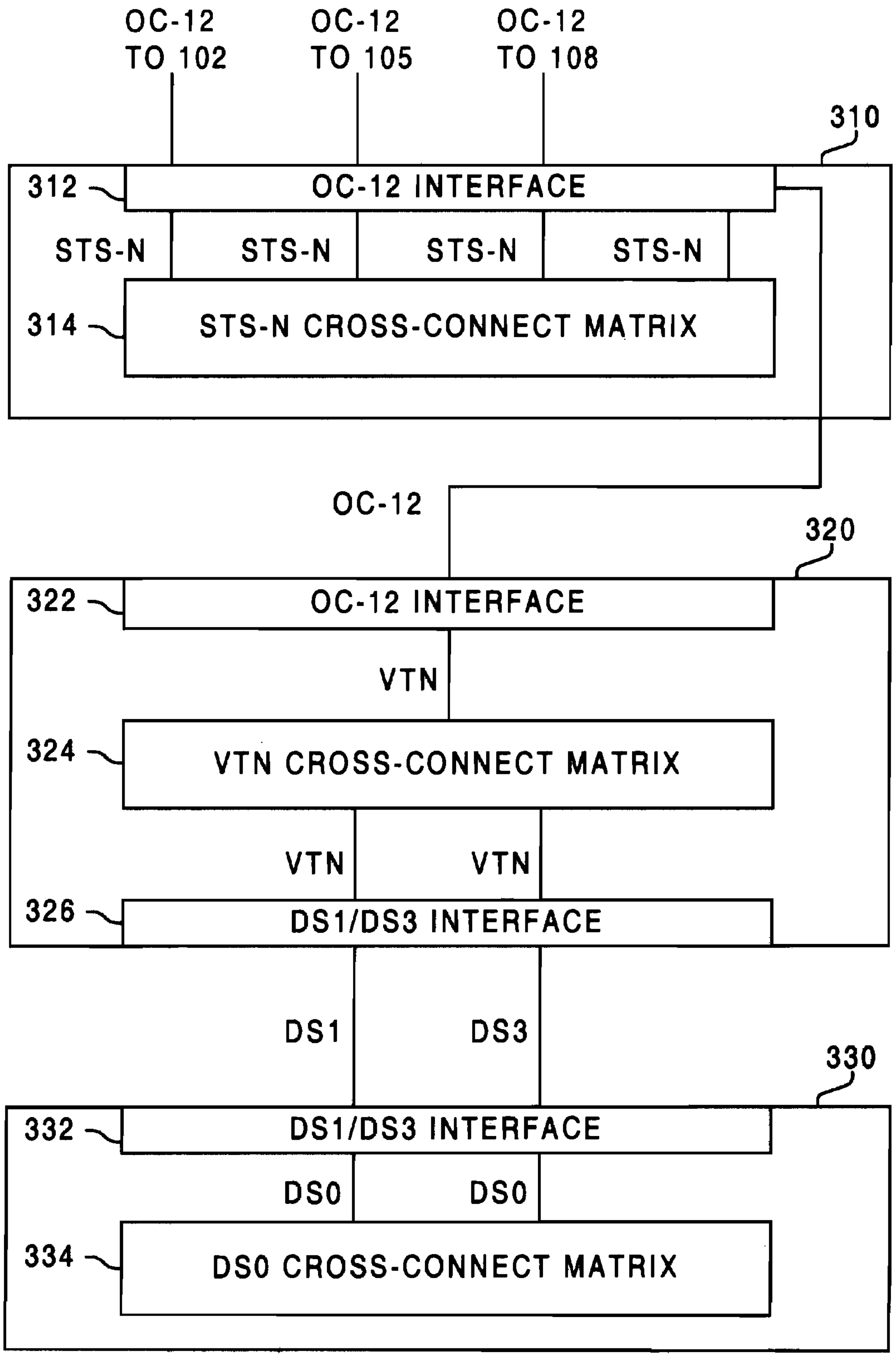

TO 103
TO 101
23
132
131
102
134
310
320
330
TO 104
TO 106
105
BB
WB
NB
135
108
141
138
TO 109
TO 111

FIGURE 5



OC-12
TO 102
OC-12
TO 105
OC-12
TO 108
310
312
OC-12 INTERFACE
STS-N
STS-N
STS-N
STS-N
314
STS-N CROSS-CONNECT MATRIX
OC-12
320
322
OC-12 INTERFACE
VTN
324
VTN CROSS-CONNECT MATRIX
VTN
VTN
326
DS1/DS3 INTERFACE
DS1
DS3
330
332
DS1/DS3 INTERFACE
DS0
DS0
334
DS0 CROSS-CONNECT MATRIX

FIGURE 6

SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE

"This application is a continuation of application Ser. No. 08/203,165 filed Feb. 28, 1994, U.S. Pat. No. 5,742,605 and currently pending".

BACKGROUND

1. Field of the Invention

The invention relates to synchronous optical networks (SONET) and specifically to the use of ring architectures that use stacked rings.

2. Description of the Prior Art

At present, proposed architectures for implementing SONET over relatively large geographic areas are Digital Cross-connect System (DCS) based. The relative size of these areas is larger than a Local Access and Transport Area (LATA), or larger than a metropolitan area. An example of such a network is an Interexchange Carrier (IXC).

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed. Often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

The prior art DCS architecture for SONET deployment in a relatively large network is depicted in FIG. **2**. DCS architecture is well-known in the art and is based on point-to-point connections which employ cross-connect switching at the network nodes where point-to-point connections intersect. In FIG. **2**, nodes **20–29** and routes **30–42** are again shown as in FIG. **1**. In FIG. **2**, they are shown connected by DCS switches **50–59** over spans **60–72** occupying physical routes **30–42**. The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only 16 ring terminals.

In the large network environment, this standard puts a severe limitation on the number of ring terminals that may be placed on a ring. A large network, such an IXC, will require hundreds or even thousands of ring terminals to deploy SONET over the large geographic area covered by the network. These large geographic areas are greater than a LATA or a metropolitan area. At only 16 ring terminals per ring, the network is required to implement a high number of rings.

For the IXC deploying SONET, ring terminals will be required at all points of presence (POPs). A POP is where the IXC provides access to its network. Additionally, ring terminals are required at points where switching or grooming capability is located. An IXC network may cover thousands of square miles and contain thousands of POPs, switching, and grooming sites. This requires thousands of ring terminals. For an IXC to comply with SONET standards, the SONET architecture would include a very large number of rings. This is because the thousands of POPs, switching, and grooming sites can only be connected at 16 ring terminals per ring.

The large number of rings coupled with the great geographic distances involved represent a costly amount of overbuild. This over build is caused by the fact that ring connections require return spans to complete the ring. The logical connections between ring terminals are called spans. These spans, in turn, require physical fiber routes to complete the ring. At present, a relatively large network is required to add an excessive amount of physical fiber routes to facilitate the high number of spans required to close the large number of rings. The rings must accommodate a large number of POPs, switching, and grooming sites.

In the local environment, this overbuild is not nearly as severe because the geographic areas are restricted within the LATA. As such, the use of ring architectures for SONET has been restricted to small geographic areas such LATAs and individual metropolitan areas. Additionally, networks may employ a single large ring which covers a large area because only one ring must be closed instead of the several rings implicated in large networks.

The large network using rings faces the problem of the extra spans required to close rings, the large number of rings, and the large geographic distances to span. These geographic distances comprise areas larger than a LATA or a metropolitan area. This problem is exacerbated by the constraint of using existing physical routes. If possible, the network tries to re-use its current physical routes in order to avoid having to acquire more physical space for its routes. Real estate costs, as well as, construction and equipment costs are a significant deterrent to acquiring new physical territory for spans. Additionally, due to the terrain problems on long routes, such as mountains, small rings may just not be possible.

The resulting inefficiency has driven the choice to use DCS architecture in the networks larger than LATAs or metropolitan areas. A DCS based network is point to point and requires no return connections. DCS architecture reduces the number of spans required to deploy SONET, and the spans required for DCS adapt well to the existing physical routes. As a result, DCS architecture is the choice at present for large network SONET architectures.

However, there are also problems caused by DCS architectures. DCS survivability is controlled by a centralized device called a Digital Cross-connect Management System (DCMS). The DCMS is well-known in the art. In FIG. **2**, DCMS **80** is shown and is connected to DCS switches **40–49** by signaling links **81**. When there is an interruption in a DCS network: 1) a DCS switch must sense the interruption, 2) the DCS switch must signal the DCMS of the condition, 3) the DCMS must determine alternate routing, 4) the DCMS must signal the alternate instructions to the DCS switches, and 5) the DCS switches must implement the alternate re-route instructions. At present, this sequence takes several minutes in a large network, such as an IXC. The several minute loss of service is a serious problem.

In contrast, rings may be self-healing. Self-healing SONET rings are detailed in ANSI Standard T1.105.XX Series. Survivability is achieved despite an interruption by routing traffic around the operational side of the ring to complete the connection. No communication with a central control device is needed. No complex re-route instructions need to be determined. This is one reason rings are the choice for networks covering small geographic areas. The small overbuild is offset by the improvement in survivability time. A network can restore service with self-healing rings in milliseconds.

At present, large networks implementing SONET face a dual problem. Ring architectures require grossly impractical overbuild for such a network in order to close the high number of large rings. These are rings which encompass areas larger than a LATA or metropolitan area. The problem is due in part to the SONET standards, the large number of network nodes, and the length of existing physical routes. Although DCS architectures relieve the overbuild problem, the survivability of a DCS based network takes several minutes for a large network. This amount of time is unacceptable. For the above reasons, relatively large networks need a SONET system that does not require impractical overbuild, yet also has millisecond survivability.

SUMMARY

The present invention is a SONET system that satisfies the need of a large network architecture that efficiently complies with the SONET standards and offers acceptable survivability. The SONET system includes SONET ring terminals which are connected by SONET spans to form a ring architecture. The ring architecture does not allow the rings to share ring terminals. Some of the rings individually encompass relatively large geographic areas. These geographic areas are larger than a LATA or a metropolitan area. Particular ring terminals on different rings are connected to provide inter connectivity among the rings. This connection may be a DCS connection. The rings are also self-healing. Self-healing rings provide excellent survivability in a large network. The logical spans of different rings can be stacked within the same physical route in order to limit the number of ring terminals per ring.

The present invention overcomes the problem of implementing a SONET system over a large geographic area by stacking rings. Stacked rings have logical spans that occupy the same physical routes. This allows the rings to be restricted to less than 16 ring terminals per ring, yet still enables the system to accommodate the numerous ring terminals required on the physical routes of a large network. By separating logical spans within the same physical route, inefficient overbuild inherent with large rings is avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a diagram depicting network nodes and physical routes without showing network connections.

FIG. **2** is a diagram depicting the prior art system using a DCS based architecture.

FIG. **3** is a diagram of a version of the present invention depicting a ring architecture.

FIG. **4** is a diagram of a version of the present invention depicting stacked rings.

FIG. **5** is a diagram of a version of the present invention depicting a DCS connection.

FIG. **6** is a diagram of a version of the present invention depicting a DCS connection.

DESCRIPTION

The present invention is a SONET system for a relatively large network that uses self-healing rings. These relatively large areas are larger than a LATA or metropolitan area. An example of such a network is an IXC. An additional feature of the invention is that the rings may be stacked. The rings are created by connecting SONET ring terminals with SONET spans and are designed to be self-healing. The ring terminals of different rings are connected to each other to provide inter connectivity among the rings. This connection may be based on DCS equipment. SONET is discussed in the SONET Sprint Technical Report of March 1993.

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed. Often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

FIG. **2** illustrates how the nodes **20–29** would be connected over routes **30–42** in a Digital Cross-connect System (DCS) based architecture. FIG. **2** is provided for comparative purposes. DCS connections are point-to-point. They form a grid with DCS switches **50–59** at the intersection points of spans **60–72** which occupy physical routes **30–42**. Each DCS switch is capable of switching traffic in any direction, as well as, adding and dropping traffic. These add/drop connections are not shown. The control over the switching is provided by Digital Cross-connect Management System (DCMS) **80**. Signalling links **81** is shown between the DCS switches **50–59** and the centralized DCMS **80**.

The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only 16 ring terminals. When a large network deploys a new architecture, it is highly desirable to reuse the existing node sites and physical routes as much as possible due to the costs of land, equipment, and construction. These conditions cause the problems discussed in the background section above.

FIG. **3** shows a version of the present invention. Nodes **20–29** are again shown as a part of the network. SONET ring terminals **100–119** are located at the nodes. Ring terminals **100–119** are comprised of SONET add/drop muxes (ADMs) which are well known in the art. Examples of ADMs are the Alcatel Models 1648SM, 1624SM, and 1612SM which respectively operate at OC-48, OC-24, and OC-12. Each ring terminal is capable of receiving, switching, and transmitting SONET traffic on the connected SONET spans. The ring terminal can add or drop traffic from the SONET rings. These add/drop connections are not shown. The ring terminals also provide grooming for the SONET traffic. These ring terminal capabilities and many others are well known in the art.

SONET spans **130–149** connect the ring terminals. Spans represent logical connections. The operation of SONET transmission using ADMs connected by fiber spans is well known in the art. These spans are logical connections which occupy physical routes, such as optical fibers. Four fiber unidirectional lines are preferred for each span. Other types of fiber lines are known, such as two and four fiber bidirectional or two fiber unidirectional, and even single fiber lines can be used. Dispersion shifted fiber is preferred, but other fiber, such as standard single mode fiber can be used.

In the present invention, the spans interconnect particular ring terminals over physical routes to form rings. As shown in FIG. **3**, ring terminals **100–103** are connected by spans **130–133** to form a ring. Other rings are formed by ring terminals **104–107**, **108–111**, **112–115**, and **116–119** which are connected respectively by spans **134–137**, **138–141**, **142–145**, and **146–149**.

Spans or groups of spans follow physical routes. These physical routes are typically comprised of optical fibers. The spans represent logical connections within the physical route. On FIG. **3**, the same physical routes from FIGS. **1** and **2** are used. As such, route **30** contains span **130**. The following is a list of route—span combinations for FIG. **3**: route **30**—span **130**, route **31**—span **133**, route **32**—span **131**, route **33**—spans **132** and **134**, route **34**—span **138**, route **35**—span **137**, route **36**—spans **135** and **141**, route **37**—span **139**, route **38**—span **136**, route **39**—spans **140** and **142** and **146**, route **40**—spans **145** and **149**, route **41**—**143** and **147**, and route **42**—spans **144** and **148**.

As stated above, in order to comply with ANSI T1.105.XX Series, each ring is restricted to a maximum of 16 ring terminals. Typically, the network will place more ring terminals on each ring than are shown on FIG. **3**, but a smaller number was used for clarity. As a practical matter, each POP, switching, and/or grooming site may require a ring terminal.

When more than 16 ring terminals are encountered, a second ring must be used. In the present invention, the second ring is stacked within the physical route of the first ring in this situation. Rings may be stacked whether or not the 16 ring terminal limit has been reached. Stacked rings maintain separate ring terminals. In FIG. **3**, the ring formed by ring terminals **112–115** is stacked on the ring formed by ring terminals **116–119**, but the rings share the same physical routes. In that way, the number of ring terminals on a physical route can be increased without increasing the number of ring terminals per ring.

For example, in the above discussed stacked rings (ring terminals **112–119**), the total number of ring terminals on the physical route is eight, but the number of ring terminals per ring is four. By stacking more rings within the physical route, the ring terminal per ring ratio can be maintained at four, but the total number of ring terminals on the physical route can be increased.

FIG. **4** shows a series of stacked rings. One ring is formed by connecting ring terminals **201–216** with SONET spans. This ring has the maximum 16 ring terminals allowed by the standards. When ring terminals **220–224** are added to the network, a second ring must be added to remain in compliance with the SONET standard. For example, take the existing physical route containing the spans that form a ring with ring terminals **201–216**. If new POPs are added along this route, more than the maximum number of 16 ring terminals are required. Thus, new ring terminals **220–224** which service the new POPs must be added to a second ring stacked on the first ring. Stacked rings do not need to be mirror images of one another. The ring formed by ring terminals **230–237** shares only some of the physical route of the other two rings and is only partially stacked. A community of interest ring may share a portion of the physical routes of several rings.

In the preferred embodiment, each span which connects two ring terminals occupies a four fiber unidirectional line. However, spans may occupy other types of lines. Spans may also share the same actual fiber between pairs of ring terminals which are still on different rings. In this case, SONET transmission on the rings is separated on the fiber by using optical couplers or wave division multiplexing (WDM). Optical couplers and WDM are well known in the art. Different rings still may not share ring terminals.

For example, in FIG. **3** ring terminals **103** and **104** are both located at node **22**. Ring terminals **102** and **105** are both located at node **23**. Ring terminals **102** and **103** are on a ring connected by span **132** over route **33**. Ring terminals **104** and **105** are on a different ring connected by span **134** over route **33**. Both spans **132** and **134** may occupy the same actual fiber in route **33** by using optical couplers or WDM to separate the rings on the same fiber. As stated, in the preferred embodiment, spans **132** and **134** would each occupy its own four fiber unidirectional line.

This stacking technique can be used to alleviate the amount of fiber required. By allowing different spans to share fiber, new rings may be added to a fiber route to accommodate new ring terminals. Thus by stacking rings within a fiber route, the amount of fiber overbuild required to close rings can be controlled. Preferably, working and protect lines are not placed within the same fiber.

In the present invention, particular ring terminals on different rings will be connected to allow transmission from ring to ring. This connection is preferably a DCS connection, but other connections are possible. Nodes at which different rings are connected are called hubs. Typically, ring terminals at the same node are all on different rings and would be interconnected with a connection to form a hub. For example on FIG. **3**, ring terminals **110**, **113**, and **117** at node **27** would be interconnected. Although the ring terminals at a node do not have to be connected, all ring terminals at the same node preferably are connected. This connection allows the ring terminals on different rings to be connected while maintaining the 16 ring terminals per ring restriction.

A DCS connection is shown in FIG. **5**. Node **23** connects different rings and includes ring terminals **102**, **105**, and **108**. These ring terminals are connected to other ring terminals at different nodes by spans **131**, **132**, **134**, **135**, **138**, and **141** respectively as shown on FIG. **3**. The add/drop connections of the ring terminals are not shown. On FIG. **5**, ring terminals **102**, **105**, and **108** are interconnected using DCS connections. The DCS connection is comprised of a DCS device or devices with the capability to interface, groom, and switch SONET traffic between ring terminals. The DCS connection can also offer local access.

In the preferred embodiment, this DCS connection is comprised of three connected devices, broadband DCS **310**, wideband DCS **320**, and narrowband DCS **330**. Those skilled in the art appreciate that the capabilities of these devices could be housed in one device or distributed among multiple devices.

Broadband DCS **310** is connected to ring terminals **102**, **105**, **108**, and wideband DCS **320** by standard fiber connections which are preferably four fiber unidirectional lines operating at OC-12. Broadband DCS **310** transmits traffic between the ring terminals. It is designed to handle traffic at or above the DS3 level, and to divert traffic below DS3 to the wideband DCS **320**.

One version of a DCS connection is shown in FIG. **6**. Broadband DCS **310** is shown. An example of broadband DCS **310** is the Alcatel Model 1633SX. Broadband DCS **310** accepts OC-12 lines from the ring terminals. Although only three ring terminals are connected to broadband DCS **310**, more ring terminals may be connected. These OC-12 lines are connected to interface **312**. Interface **312** breaks down each OC-12 signal into component STS signals. These signals are in turn, connected to cross-connect matrix **314** for grooming. This matrix accepts signals at the STS level or higher, and is capable of establishing a connection from any STS to any other STS using time slot interchange. Typically, these connections are pre-determined and programmed into broadband DCS **310**. Although not shown, broadband DCS **310** could accept local access signals into an interface, convert these signals into STS signals, and connect them to cross-connect matrix **314** for grooming. As such, broadband DCS **310** could accept SONET signals from both the rings and local sources and connect them.

Wideband DCS **320** is shown. An example of wideband DCS **320** is the Tellabs Model 5500. Wideband DCS **320** accepts the OC-12 signal from broadband DCS **310** into interface **322**. These signals are broken down into component VT signals and connected to cross-connect matrix **324** which has the capability to connect any VT to any other VT. Although not shown, local access could also be accepted in a similar manner. Interface **326** accepts a DS**1** and a DS**3** connection from narrowband DCS **330**. Interface **326** maps and grooms these signals into VT signals and connects them to cross-connect matrix **324**.

Narrowband DCS **330** is shown. An example of the narrowband DCS is the Digital Switch Corporation Model CS-1L. It accepts the DS**1** and DS**3** signals from wideband DCS **320** into interface **332**. These signals are converted into DS**0** signals and connected to cross-connect matrix **334** which has the capability to connect any DS**0** to any other DS**0**. Local access can also be accepted.

Although, the preferred signal levels for interface, grooming, and cross-connection are listed above, those skilled in the art are aware that other choices would be operational. The present invention is not restricted to these listed levels, but they are given as preferred and operational levels. The DCS connection provided by these devices is capable of processing signals transmitted between rings. This processing may occur at different signal levels. The DCS connection also provides local access. In this way, connectivity is provided between the ring terminals of different rings, and to local sources. The DCS connection formed may be any device or combination of devices with the above capabilities. For purposes of redundancy, additional back-up DCS connection capability can be added at a node.

Other connections are also operational in the context of the present invention. In one embodiment, direct cabling at OC-N or STS-N could be used to connect ring terminals on different rings. In another embodiment, an ATM switch with the DCS functionality described could be used to connect the ring terminals of different rings.

At present, SONET standards are driving the choice of OC-12 transmission. This causes a problem since there are no devices currently available that accept, groom, and connect OC-12 traffic between SONET rings. This is another reason that networks have opted for a DCS based architecture. The DCS architecture does not require an OC-12 interface between rings which is currently unavailable. The present invention solves the problem of ring connectivity at OC-12 with the DCS connection.

As stated above, ring architectures solve the problem of excessive survivability time because they can be designed to be self-healing. At present, the benefit of self-healing rings is outweighed in the large network environment because of the impractical overbuild and connectivity problems. However, by stacking rings, and using a DCS connection between rings, the present invention overcomes these problems. As a result, self-healing ring technology can be employed in the present invention to provide significantly improved survivability features.

There are three basic types of self-healing ring methods: path switched unidirectional, line switched two fiber bidirectional, and line switched four fiber bidirectional. Line switched four fiber bidirectional is preferred. These formats for self-healing rings are known in the art, but they have yet to be applied within the large network environment because of the above stated problems with rings in networks larger than LATAs or metropolitan areas. The present invention employs self-healing capability in particular ring terminals on each ring. Problems are avoided by routing the traffic around the operational side of the ring to the destination.

As a result, the present invention provides a SONET system that employs self-healing rings which can efficiently span large geographic distances. Although it is preferred to minimize the size of rings, large rings are inherent to the large network environment. An IXC is an example of a large network, but in the present invention, a network which encompasses an area larger than a LATA or a metropolitan area is considered a relatively large network. Traffic can thus be transmitted from LATA to LATA, or metropolitan area to metropolitan area and maintain millisecond survivability. Current DCS based SONET architectures cannot provide this performance in the large network environment. Current SONET ring architectures are restricted to use in small geographic areas, such as LATAs and metropolitan areas, or to single large rings. By featuring stacked self-healing SONET rings with DCS connections, the present invention eliminates these current problems.

What is claimed is:

1. A Synchronous Optical Network (SONET) system comprising:

a first SONET ring that occupies a physical route;

a second SONET ring that shares at least a portion of the physical route with the first SONET ring but that does not share ring terminals or ring spans with the first SONET ring; and

a connection system coupled to the first SONET ring and to the second SONET ring and configured to groom SONET traffic at a Synchronous Transport Signal (STS) level and a Virtual Tributary (VT) level.

2. The SONET system of claim **1** wherein the connection system is further configured to groom the SONET traffic at a DSO level.

3. The SONET system of claim **1** wherein the connection system is further configured to provide access to the first SONET ring and to the second SONET ring.

4. The SONET system of claim **1** wherein the connection system is further configured to switch the SONET traffic.

5. The SONET system of claim **1** wherein the connection system includes an Asynchronous Transfer Mode (ATM) switch.

6. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM).

7. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM) to separate the ring spans of the first SONET ring from the ring spans of the second SONET ring.

8. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are each comprised of four optical fibers.

9. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring have a work line and a protect line in separate optical fibers.

10. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are self healing.

11. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are line switched.

12. The SONET system of claim **1** comprising another connection system coupled to the first SONET ring and to the second SONET ring and configured to groom the SONET traffic at the Synchronous Transport Signal (STS) level and the Virtual Tributary (VT) level.

13. The SONET system of claim **12** wherein the other connection system is further configured to groom the SONET traffic at the DS**0** level.

14. The SONET system of claim **12** wherein the other connection system is further configured to provide access to the first SONET ring and to the second SONET ring.

15. The SONET system of claim **12** wherein the other connection system is further configured to switch the SONET traffic.

16. The SONET system of claim **12** wherein the other connection system includes another Asynchronous Transfer Mode (ATM) switch.

17. A Synchronous Optical Network (SONET) system comprising:

a first SONET ring that occupies a physical route;

a second SONET ring that shares at least a portion of the physical route with the first SONET ring but that does not share ring terminals or ring spans with the first SONET ring;

a first connection system coupled to the first SONET ring and to the second SONET ring and configured to groom SONET traffic; and

a second connection system coupled to the first SONET ring and to the second SONET ring and configured to groom the SONET traffic.

18. The SONET system of claim **17** wherein the first connection system and the second connection system are further configured to provide access to the first SONET ring and to the second SONET ring.

19. The SONET system of claim **17** wherein the first connection system and the second connection system are further configured to switch the SONET traffic.

20. The SONET system of claim **17** wherein the first connection system and the second connection system each include an Asynchronous Transfer Mode (ATM) switch.

21. The SONET system of claim **17** wherein the first SONFT ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM).

22. The SONET system of claim **17** wherein the first SONET ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM) to separate the ring spans of the first SONET ring from the ring spans of the second SONET ring.

23. The SONET system of claim **17** wherein the first SONET ring and the second SONET ring are each comprised of four optical fibers.

24. The SONET system of claim **17** wherein the first SONET ring and the second SONET ring have a work line and a protect line in separate optical fibers.

25. The SONET system of claim **17** wherein the first SONET ring and the second SONET ring are self healing.

26. The SONET system of claim **17** wherein the first SONET ring and the second SONET ring are line switched.

* * * * *

EXHIBIT C

US006452931B1

(12) **United States Patent**
Norman, Jr.

(10) **Patent No.: US 6,452,931 B1**
(45) **Date of Patent: Sep. 17, 2002**

(54) **SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE**

(75) Inventor: **Charles William Norman, Jr.**, Overland Park, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/611,619**

(22) Filed: **Jul. 7, 2000**

Related U.S. Application Data

(63) Continuation of application No. 08/974,774, filed on Nov. 20, 1997, now Pat. No. 6,108,339, which is a continuation of application No. 08/203,165, filed on Feb. 28, 1994, now Pat. No. 5,742,605.

(51) **Int. Cl.**[7] **H04L 12/28**; H04L 12/56
(52) **U.S. Cl.** **370/405**
(58) **Field of Search** 370/216, 221, 370/222, 223, 400, 401, 402, 403, 404, 405, 452, 535–541

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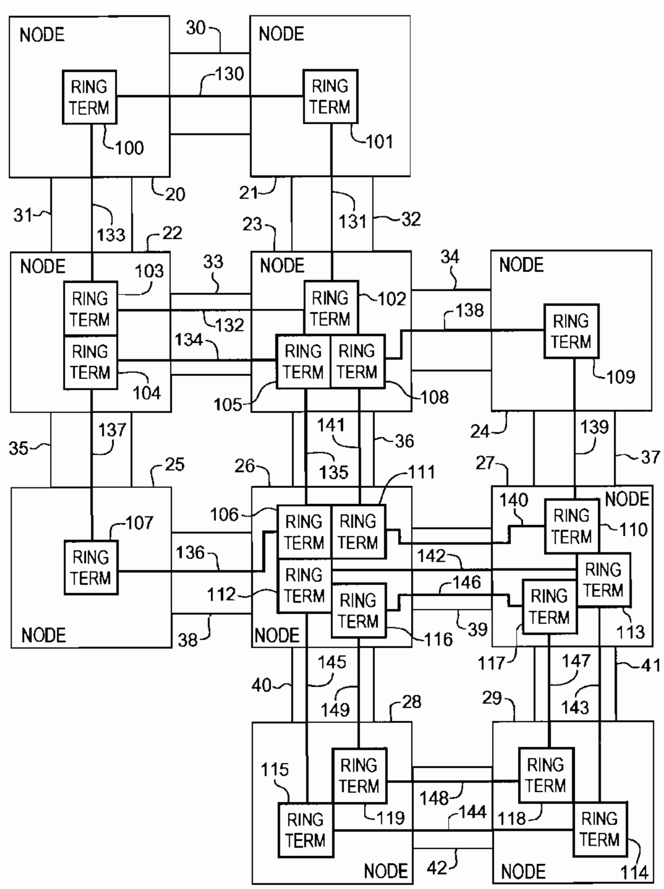
Primary Examiner—Ajit Patel
(74) *Attorney, Agent, or Firm*—Harley R. Ball; Steven J. Funk; Kevin D. Robb

(57) **ABSTRACT**

The present invention is a SONET system for use in large geographic areas, such as areas encompassed by an IXC network, or which are larger than a LATA or a metropolitan area. The system uses self-healing rings which are interconnected. Some of the rings are stacked within the same physical routes in order to minimize the number of ring terminals on each ring.

18 Claims, 6 Drawing Sheets



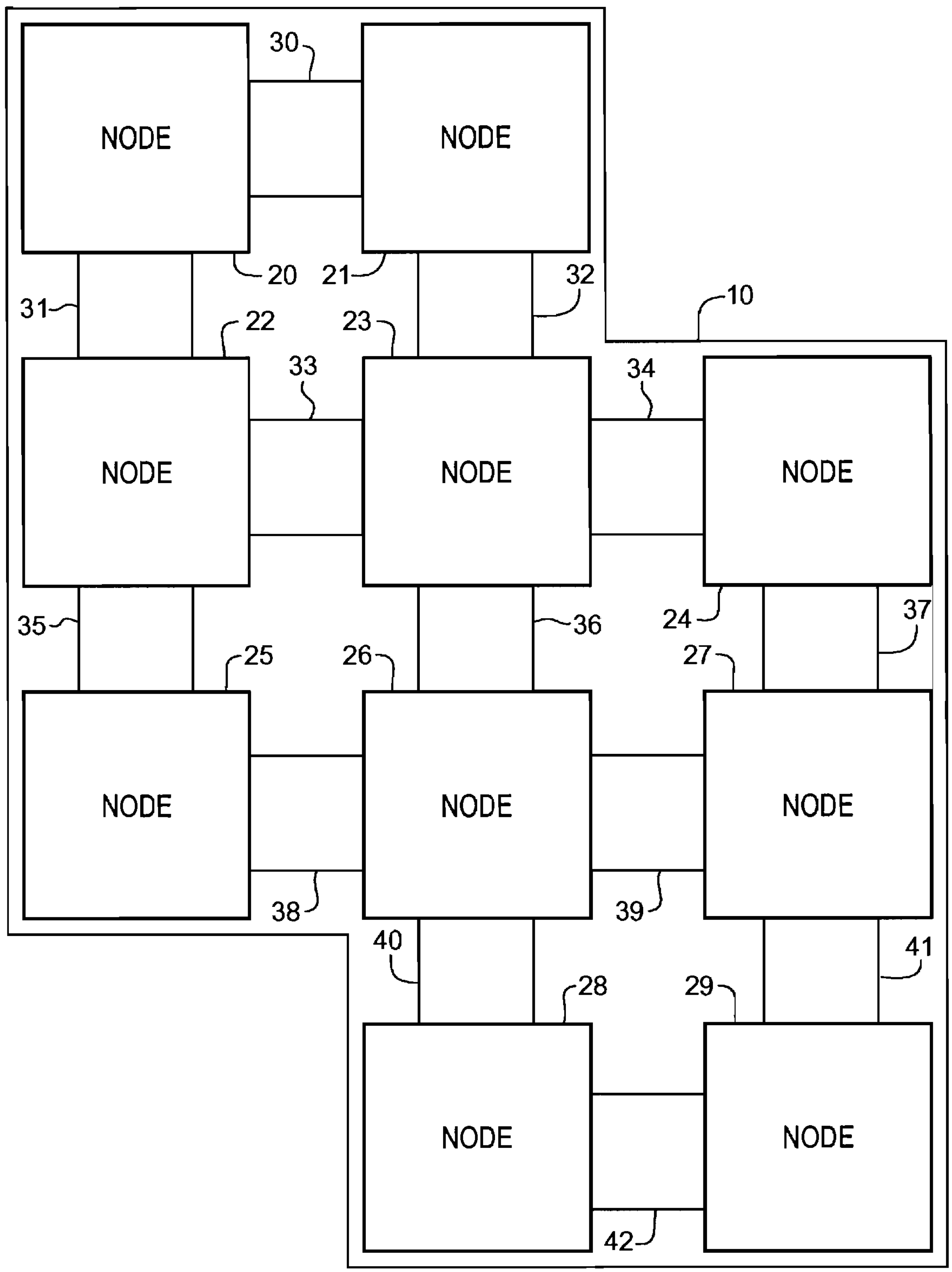


FIG. 1
PRIOR ART

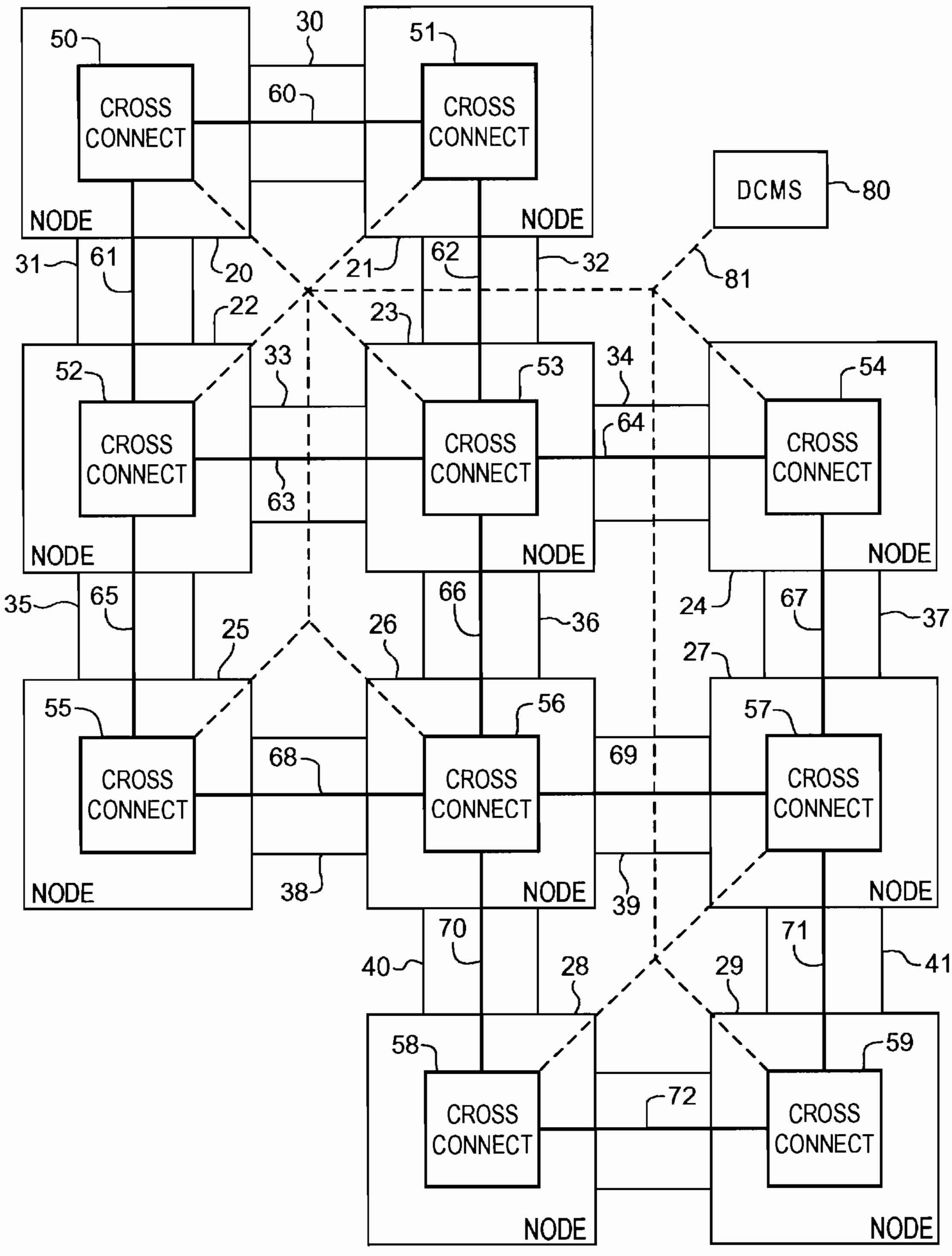


FIG. 2
PRIOR ART

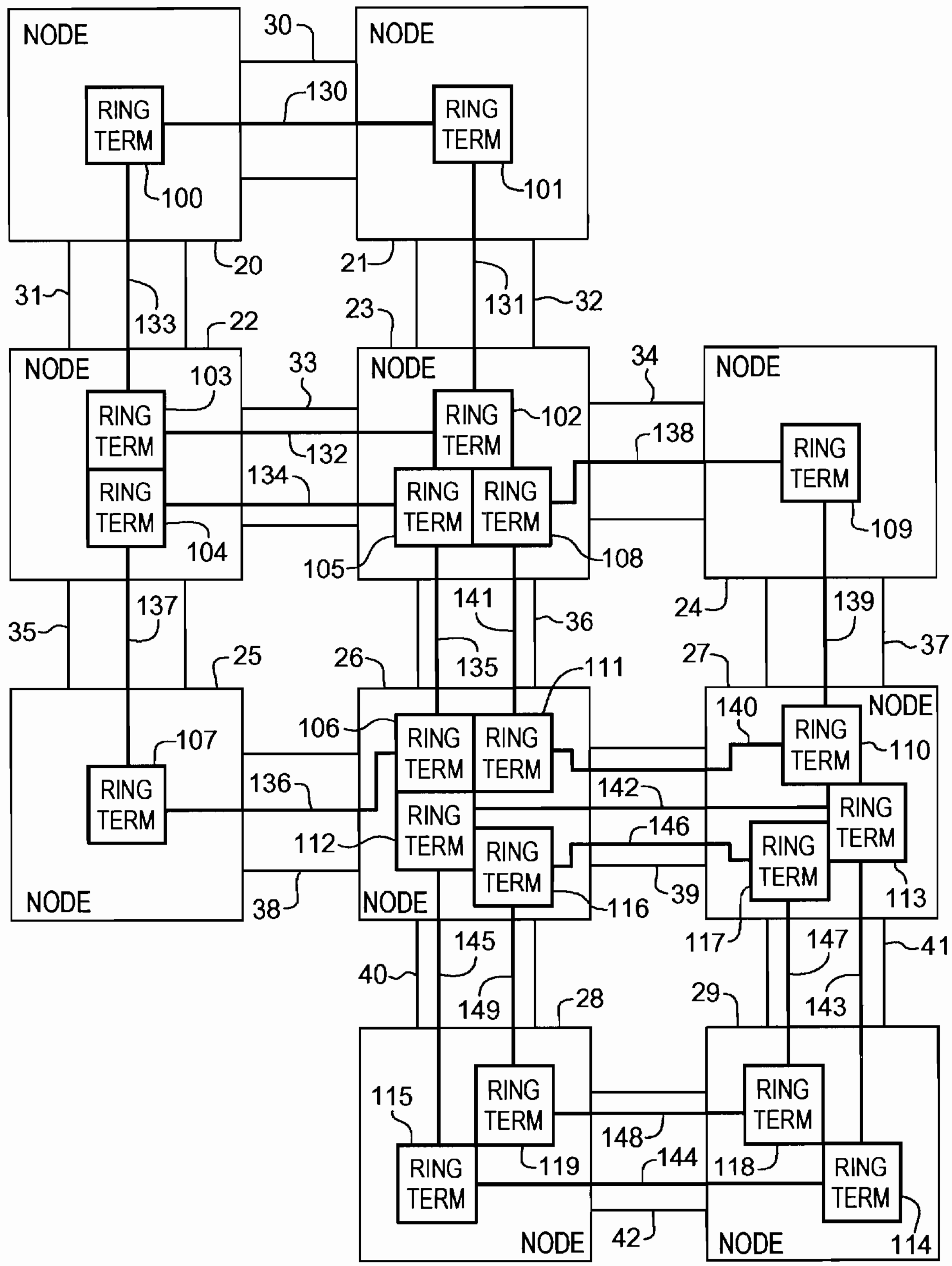
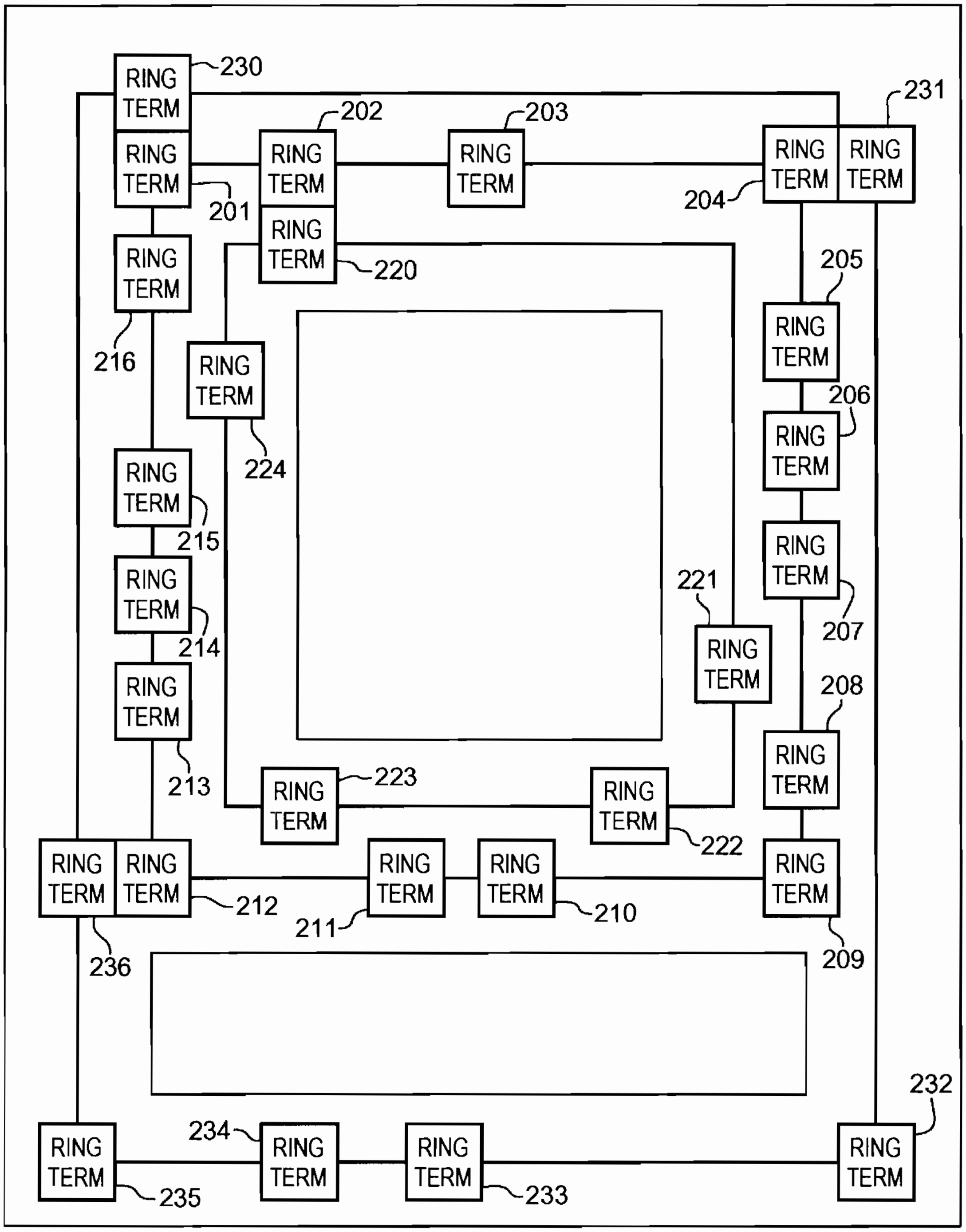

NODE
NODE
NODE
NODE
NODE
NODE
NODE
NODE
NODE
RING TERM
30
130
100
101
20
21
31
133
22
23
131
32
33
34
103
102
132
138
134
105
104
108
109
141
36
24
139
35
137
25
26
135
111
27
37
140
110
107
106
136
142
146
112
113
116
39
38
117
145
147
41
40
149
28
29
143
115
148
144
119
118
42
114

FIG. 3



RING TERM
230
231
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
220
221
222
223
224
232
233
234
235
236

FIG. 4

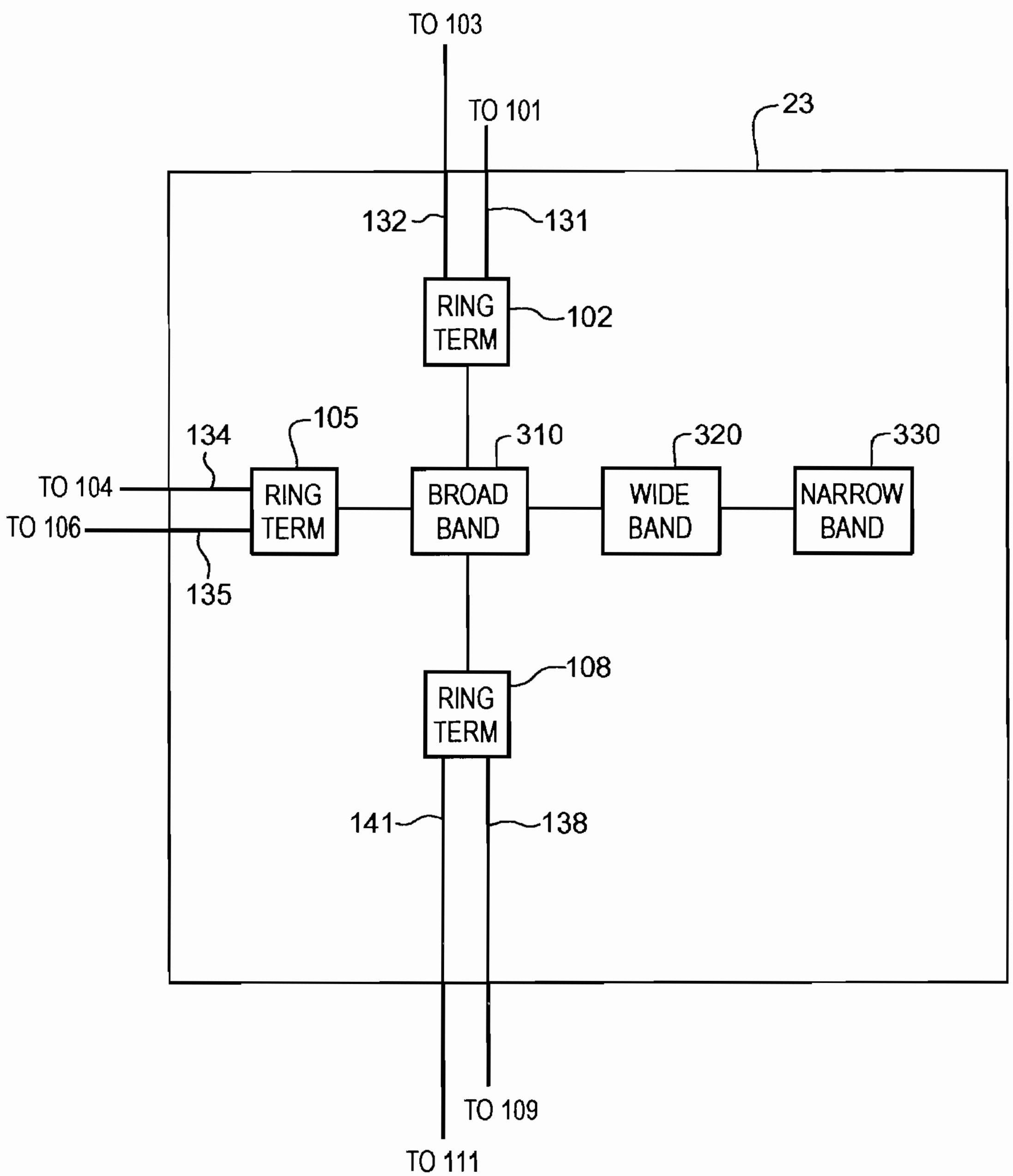

TO 103
TO 101
23
132
131
RING TERM
102
105
134
310
320
330
TO 104
TO 106
RING TERM
BROAD BAND
WIDE BAND
NARROW BAND
135
108
RING TERM
141
138
TO 109
TO 111

FIG. 5

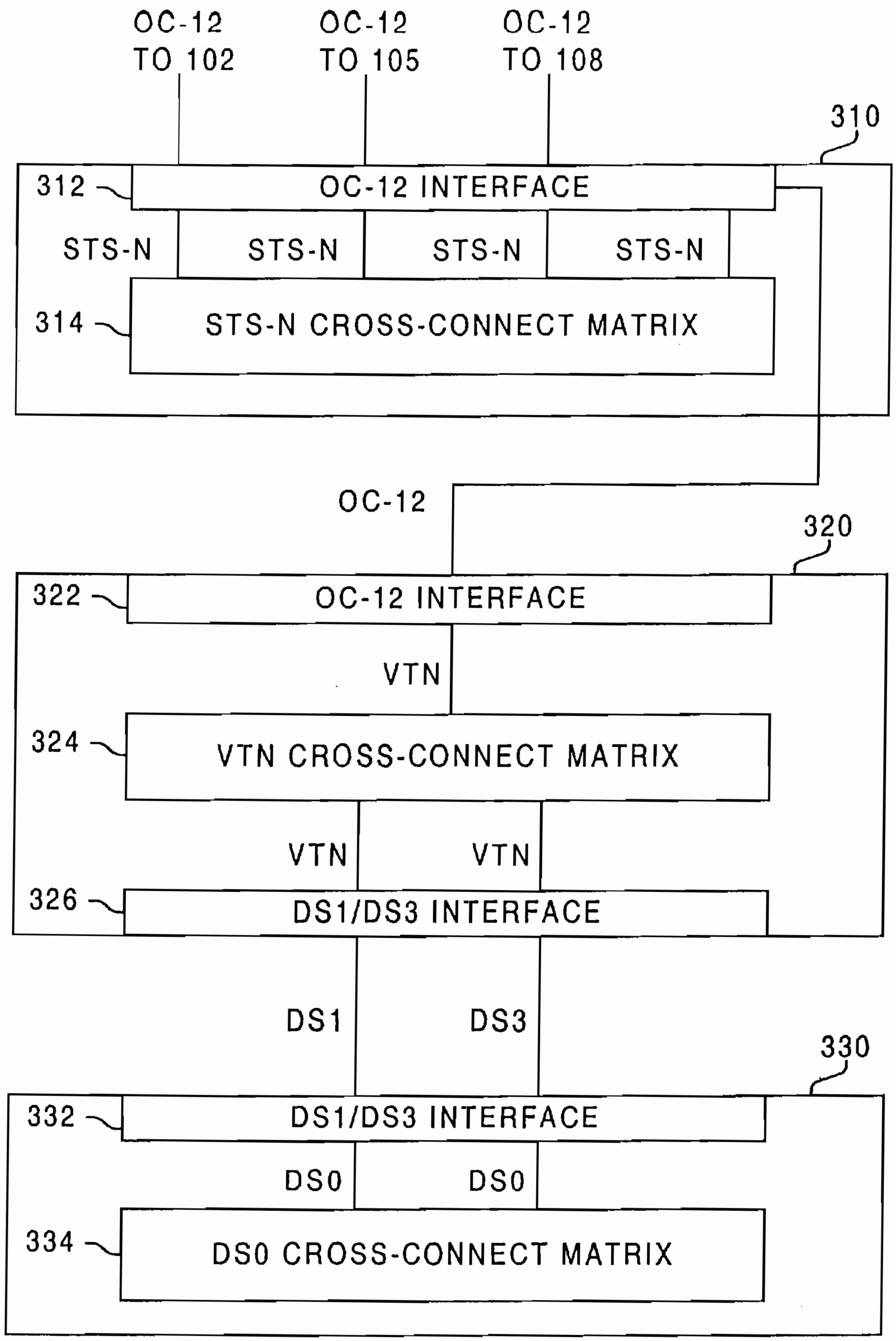

OC-12
TO 102
OC-12
TO 105
OC-12
TO 108
310
312
OC-12 INTERFACE
STS-N
STS-N
STS-N
STS-N
314
STS-N CROSS-CONNECT MATRIX
OC-12
320
322
OC-12 INTERFACE
VTN
324
VTN CROSS-CONNECT MATRIX
VTN
VTN
326
DS1/DS3 INTERFACE
DS1
DS3
330
332
DS1/DS3 INTERFACE
DS0
DS0
334
DS0 CROSS-CONNECT MATRIX

FIGURE 6

SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE

RELATED APPLICATIONS

This application is a continuation of prior application Ser. No. 08/974,774, entitled "A SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE", filed Nov. 20, 1997 now U.S. Pat. No. 6,108,339; which is a continuation of prior application Ser. No. 08/203,165, entitled "A SYNCHRONOUS OPTICAL NETWORK USING A RING ARCHITECTURE", filed Feb. 28, 1994, issued as U.S. Pat. No. 5,742,605. All of the above-related applications are hereby incorporated by reference into this application.

BACKGROUND

1. Field of the Invention

The invention relates to synchronous optical networks (SONET) and specifically to the use of ring architectures that use stacked rings.

2. Description of the Prior Art

At present, proposed architectures for implementing SONET over relatively large geographic areas are Digital Cross-connect System (DCS) based. The relative size of these areas is larger than a Local Access and Transport Area (LATA), or larger than a metropolitan area. An example of such a network is an Interexchange Carrier (IXC).

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

The prior art DCS architecture for SONET deployment in a relatively large network is depicted in FIG. **2**. DCS architecture is well-known in the art and is based on point-to-point connections which employ cross-connect switching at the network nodes where point-to-point connections intersect. In FIG. **2**, nodes **20–29** and routes **30–42** are again shown as in FIG. **1**. In FIG. **2**, they are shown connected by DCS switches **50–59** over spans **60–72** occupying physical routes **30–42**. The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only 16 ring terminals.

In the large network environment, this standard puts a severe limitation on the number of ring terminals that may be placed on a ring. A large network, such an IXC, will require hundreds or even thousands of ring terminals to deploy SONET over the large geographic area covered by the network. These large geographic areas are greater than a

LATA or a metropolitan area. At only 16 ring terminals per ring, the network is required to implement a high number of rings.

For the IXC deploying SONET, ring terminals will be required at all points of presence (POPs). A POP is where the IXC provides access to its network. Additionally, ring terminals are required at points where switching or grooming capability is located. An IXC network may cover thousands of square miles and contain thousands of POPs, switching, and grooming sites. This requires thousands of ring terminals. For an IXC to comply with SONET standards, the SONET architecture would include a very large number of rings. This is because the thousands of POPs, switching, and grooming sites can only be connected at 16 ring terminals per ring.

The large number of rings coupled with the great geographic distances involved represent a costly amount of overbuild. This overbuild is caused by the fact that ring connections require return spans to complete the ring. The logical connections between ring terminals are called spans. These spans, in turn, require physical fiber routes to complete the ring. At present, a relatively large network is required to add an excessive amount of physical fiber routes to facilitate the high number of spans required to close the large number of rings. The rings must accommodate a large number of POPs, switching, and grooming sites.

In the local environment, this overbuild is not nearly as severe because the geographic areas are restricted within the LATA. As such, the use of ring architectures for SONET has been restricted to small geographic areas such LATAs and individual metropolitan areas. Additionally, networks may employ a single large ring which covers a large area because only one ring must be closed instead of the several rings implicated in large networks.

The large network using rings faces the problem of the extra spans required to close rings, the large number of rings, and the large geographic distances to span. These geographic distances comprise areas larger than a LATA or a metropolitan area. This problem is exacerbated by the constraint of using existing physical routes. If possible, the network tries to re-use its current physical routes in order to avoid having to acquire more physical space for its routes. Real estate costs, as well as, construction and equipment costs are a significant deterrent to acquiring new physical territory for spans. Additionally, due to the terrain problems on long routes, such as mountains, small rings may just not be possible.

The resulting inefficiency has driven the choice to use DCS architecture in the networks larger than LATAs or metropolitan areas. A DCS based network is point to point and requires no return connections. DCS architecture reduces the number of spans required to deploy SONET, and the spans required for DCS adapt well to the existing physical routes. As a result, DCS architecture is the choice at present for large network SONET architectures.

However, there are also problems caused by DCS architectures. DCS survivability is controlled by a centralized device called a Digital Cross-connect Management System (DCMS). The DCMS is well-known in the art. In FIG. **2**, DCMS **80** is shown and is connected to DCS switches **50–59** by signaling links **81**. When there is an interruption in a DCS network: 1) a DCS switch must sense the interruption, 2) the DCS switch must signal the DCMS of the condition, 3) the DCMS must determine alternate routing, 4) the DCMS must signal the alternate instructions to the DCS switches, and 5) the DCS switches must implement the alternate re-route instructions. At present, this sequence takes several minutes in a large network, such as IXC. The several minute loss of service is a serious problem.

In contrast, rings may be self-healing. Self-healing SONET rings are detailed in ANSI Standard T1.105.XX Series. Survivability is achieved despite an interruption by routing traffic around the operational side of the ring to complete the connection. No communication with a central control device is needed. No complex re-route instructions need to be determined. This is one reason rings are the choice for networks covering small geographic areas. The small overbuild is offset by the improvement in survivability time. A network can restore service with self-healing rings in milliseconds.

At present, large networks implementing SONET face a dual problem. Ring architectures require grossly impractical overbuild for such a network in order to close the high number of large rings. These are rings which encompass areas larger than a LATA or metropolitan area. The problem is due in part to the SONET standards, the large number of network nodes, and the length of existing physical routes. Although DCS architectures relieve the overbuild problem, the survivability of a DCS based network takes several minutes for a large network. This amount of time is unacceptable. For the above reasons, relatively large networks need a SONET system that does not require impractical overbuild, yet also has millisecond survivability.

SUMMARY

The present invention is a SONET system that satisfies the need of a large network architecture that efficiently complies with the SONET standards and offers acceptable survivability. The SONET system includes SONET ring terminals which are connected by SONET spans to form a ring architecture. The ring architecture does not allow the rings to share ring terminals. Some of the rings individually encompass relatively large geographic areas. These geographic areas are larger than a LATA or a metropolitan area. Particular ring terminals on different rings are connected to provide interconnectivity among the rings. This connection may be a DCS connection. The rings are also self-healing. Self-healing rings provide excellent survivability in a large network. The logical spans of different rings can be stacked within the same physical route in order to limit the number of ring terminals per ring.

The present invention overcomes the problem of implementing a SONET system over a large geographic area by stacking rings. Stacked rings have logical spans that occupy the same physical routes. This allows the rings to be restricted to less than 16 ring terminals per ring, yet still enables the system to accommodate the numerous ring terminals required on the physical routes of a large network. By separating logical spans within the same physical route, inefficient overbuild inherent with large rings is avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, claims, and drawings where:

FIG. **1** is a diagram depicting network nodes and physical routes without showing network connections.

FIG. **2** is a diagram depicting the prior art system using a DCS based architecture.

FIG. **3** is a diagram of a version of the present invention depicting a ring architecture.

FIG. **4** is a diagram of a version of the present invention depicting stacked rings.

FIG. **5** is a diagram of a version of the present invention depicting a DCS connection.

FIG. **6** is a diagram of a version of the present invention depicting a DCS connection.

DESCRIPTION

The present invention is a SONET system for a relatively large network that uses self-healing rings. These relatively large areas are larger than a LATA or metropolitan area. An example of such a network is an IXC. An additional feature of the invention is that the rings may be stacked. The rings are created by connecting SONET ring terminals with SONET spans and are designed to be self-healing. The ring terminals of different rings are connected to each other to provide interconnectivity among the rings. This connection may be based on DCS equipment. SONET is discussed in the SONET Sprint Technical Report of March 1993.

In FIG. **1**, network **10** is depicted without actual connections. For clarity, the network is shown as encompassing a geometric area with short routes, but clearly, networks may span entire countries and continents. Network **10** nodes **20–29** are shown. A node is a site in the network where traffic is processed. Often, this processing involves switching, providing access, and grooming. Additionally, physical routes **30–42** are shown between nodes **20–29**. The physical routes do not represent actual connections, but they represent the physical space that the actual connections may occupy. For example, the two lines between nodes **20** and **21** define physical route **30** between nodes **20** and **21**. These physical routes are typically optical fibers. Logical connections, or spans, occupy is these physical fiber routes. A network will have many more nodes and longer routes than are shown on FIG. **1**, but the amount shown is restricted for clarity.

FIG. **2** illustrates how the nodes **20–29** would be connected over routes **30–42** in a Digital Cross-connect System (DCS) based architecture. FIG. **2** is provided for comparative purposes. DCS connections are point-to-point. They form a grid with DCS switches **50–59** at the intersection points of spans **60–72** which occupy physical routes **30–42**. Each DCS switch is capable of switching traffic in any direction, as well as, adding and dropping traffic. These add/drop connections are not shown. The control over the switching is provided by Digital Cross-connect Management System (DCMS) **80**. Signalling links **81** is shown between the DCS switches **50–59** and the centralized DCMS **80**.

The current selection of a DCS architecture for SONET in a relatively large network is dictated by the SONET standards. These standards make rings impractical for these larger networks which encompass areas greater than a LATA or a metropolitan area. ANSI T1.105.XX Series requires that a SONET ring may contain a maximum of only **16** ring terminals. When a large network deploys a new architecture, it is highly desirable to reuse the existing node sites and physical routes as much as possible due to the costs of land, equipment, and construction. These conditions cause the problems discussed in the background section above.

FIG. **3** shows a version of the present invention. Nodes **20–29** are again shown as a part of the network. SONET ring terminals **100–119** are located at the nodes. Ring terminals **100–119** are comprised of SONET add/drop muxes (ADMs) which are well known in the art. Examples of ADMs are the Alcatel Models 1648SM, 1624SM, and 1612SM which respectively operate at OC-48, OC-24, and OC-12. Each ring terminal is capable of receiving, switching, and transmitting SONET traffic on the connected SONET spans. The ring terminal can add or drop traffic from the SONET rings. These add/drop connections are not shown. The ring terminals also provide grooming for the SONET traffic. These ring terminal capabilities and many others are well known in the art.

SONET spans **130–149** connect the ring terminals. Spans represent logical connections. The operation of SONET transmission using ADMs connected by fiber spans is well known in the art. These spans are logical connections which occupy physical routes, such as optical fibers. Four fiber unidirectional lines are preferred for each span. Other types of fiber lines are known, such as two and four fiber bidirectional or two fiber unidirectional, and even single fiber lines can be used. Dispersion shifted fiber is preferred, but other fiber, such as standard single mode fiber can be used.

In the present invention, the spans interconnect particular ring terminals over physical routes to form rings. As shown in FIG. **3**, ring terminals **100–103** are connected by spans **130–133** to form a ring. Other rings are formed by ring terminals **104–107**, **108–111**, **112–115**, and **116–119** which are connected respectively by spans **134–137**, **138–141**, **142–145**, and **146–149**.

Spans or groups of spans follow physical routes. These physical routes are typically comprised of optical fibers. The spans represent logical connections within the physical route. on FIG. **3**, the same physical routes from FIGS. **1** and **2** are used. As such, route **30** contains span **130**. The following is a list of route—span combinations for FIG. **3**: route **30**—span **130**, route **31**—span **133**, route **32**—span **131**, route **33**—spans **132** and **134**, route **34**—span **138**, route **35**—span **137**, route **36**—spans **135** and **141**, route **37**—span **139**, route **38**—span **136**, route **39**—spans **140** and **142** and **146**, route **40**—spans **145** and **149**, route **41**—**143** and **147**, and route **42**—spans **144** and **148**.

As stated above, in order to comply with ANSI T1.105.XX Series, each ring is restricted to a maximum of 16 ring terminals. Typically, the network will place more ring terminals on each ring than are shown on FIG. **3**, but a smaller number was used for clarity. As a practical matter, each POP, switching, and/or grooming site may require a ring terminal.

When more than 16 ring terminals are encountered, a second ring must be used. In the present invention, the second ring is stacked within the physical route of the first ring in this situation. Rings may be stacked whether or not the 16 ring terminal limit has been reached. Stacked rings maintain separate ring terminals. In FIG. **3**, the ring formed by ring terminals **112–115** is stacked on the ring formed by ring terminals **116–119**, but the rings share the same physical routes. In that way, the number of ring terminals on a physical route can be increased without increasing the number of ring terminals per ring.

For example, in the above discussed stacked rings (ring terminals **112–119**), the total number of ring terminals on the physical route is eight, but the number of ring terminals per ring is four. By stacking more rings within the physical route, the ring terminal per ring ratio can be maintained at four, but the total number of ring terminals on the physical route can be increased.

FIG. **4** shows a series of stacked rings. One ring is formed by connecting ring terminals **201–216** with SONET spans. This ring has the maximum 16 ring terminals allowed by the standards. When ring terminals **220–224** are added to the network, a second ring must be added to remain in compliance with the SONET standard. For example, take the existing physical route containing the spans that form a ring with ring terminals **201–216**. If new POPs are added along this route, more than the maximum number of 16 ring terminals are required. Thus, new ring terminals **220–224** which service the new POPs must be added to a second ring stacked on the first ring. Stacked rings do not need to be mirror images of one another. The ring formed by ring terminals **230–237** shares only some of the physical route of the other two rings and is only partially stacked. A community of interest ring may share a portion of the physical routes of several rings.

In the preferred embodiment, each span which connects two ring terminals occupies a four fiber unidirectional line. However, spans may occupy other types of lines. Spans may also share the same actual fiber between pairs of ring terminals which are still on different rings. In this case, SONET transmission on the rings is separated on the fiber by using optical couplers or wave division multiplexing (WDM). Optical couplers and WDM are well known in the art. Different rings still may not share ring terminals.

For example, in FIG. **3** ring terminals **103** and **104** are both located at node **22**. Ring terminals **102** and **105** are both located at node **23**. Ring terminals **102** and **103** are on a ring connected by span **132** over route **33**. Ring terminals **104** and **105** are on a different ring connected by span **134** over route **33**. Both spans **132** and **134** may occupy the same actual fiber in route **33** by using optical couplers or WDM to separate the rings on the same fiber. As stated, in the preferred embodiment, spans **132** and **134** would each occupy its own four fiber unidirectional line.

This stacking technique can be used to alleviate the amount of fiber required. By allowing different spans to share fiber, new rings may be added to a fiber route to accommodate new ring terminals. Thus by stacking rings within a fiber route, the amount of fiber overbuild required to close rings can be controlled. Preferably, working and protect lines are not placed within the same fiber.

In the present invention, particular ring terminals on different rings will be connected to allow transmission from ring to ring. This connection is preferably a DCS connection, but other connections are possible. Nodes at which different rings are connected are called hubs. Typically, ring terminals at the same node are all on different rings and would be interconnected with a connection to form a hub. For example on FIG. **3**, ring terminals **110**, **113**, and **117** at node **27** would be interconnected. Although the ring terminals at a node do not have to be connected, all ring terminals at the same node preferably are connected. This connection allows the ring terminals on different rings to be connected while maintaining the **16** ring terminals per ring restriction.

A DCS connection is shown in FIG. **5**. Node **23** connects different rings and includes ring terminals **102**, **105**, and **108**. These ring terminals are connected to other ring terminals at different nodes by spans **131**, **132**, **134**, **135**, **138**, and **141** respectively as shown on FIG. **3**. The add/drop connections of the ring terminals are not shown. On FIG. **5**, ring terminals **102**, **105**, and **108** are interconnected using DCS connections. The DCS connection is comprised of a DCS device or devices with the capability to interface, groom, and switch SONET traffic between ring terminals. The DCS connection can also offer local access.

In the preferred embodiment, this DCS connection is comprised of three connected devices, broadband DCS **310**, wideband DCS **320**, and narrowband DCS **330**. Those skilled in the art appreciate that the capabilities of these devices could be housed in one device or distributed among multiple devices.

Broadband DCS **310** is connected to ring terminals **102**, **105**, **108**, and wideband DCS **320** by standard fiber connections which are preferably four fiber unidirectional lines operating at OC-12. Broadband DCS **310** transmits traffic between the ring terminals. It is designed to handle traffic at or above the DS3 level, and to divert traffic below DS**3** to the wideband DCS **320**.

One version of a DCS connection is shown in FIG. **6**. Broadband DCS **310** is shown. An example of broadband DCS **310** is the Alcatel Model 1633SX. Broadband DCS **310** accepts OC-12 lines from the ring terminals. Although only three ring terminals are connected to broadband DCS **310**, more ring terminals may be connected. These OC-12 lines are connected to interface **312**. Interface **312** breaks down each OC-12 signal into component STS signals. These signals are in turn, connected to cross-connect matrix **314** for grooming. This matrix accepts signals at the STS level or higher, and is capable of establishing a connection from any STS to any other STS using time slot interchange. Typically, these connections are pre-determined and programmed into broadband DCS **310**. Although not shown, broadband DCS **310** could accept local access signals into an interface, convert these signals into STS signals, and connect them to cross-connect matrix **314** for grooming. As such, broadband DCS **310** could accept SONET signals from both the rings and local sources and connect them.

Wideband DCS **320** is shown. An example of wideband DCS **320** is the Tellabs Model 5500. Wideband DCS **320** accepts the OC-12 signal from broadband DCS **310** into interface **322**. These signals are broken down into component VT signals and connected to cross-connect matrix **324** which has the capability to connect any VT to any other VT. Although not shown, local access could also be accepted in a similar manner. Interface **326** accepts a DS**1** and a DS**3** connection from narrowband DCS **330**. Interface **326** maps and grooms these signals into VT signals and connects them to cross-connect matrix **324**.

Narrowband DCS **330** is shown. An example of the narrowband DCS is the Digital Switch Corporation Model CS-1L. It accepts the DS**1** and DS**3** signals from wideband DCS **320** into interface **332**. These signals are converted into DS**0** signals and connected to cross-connect matrix **334** which has the capability to connect any DSO to any other DS**0**. Local access can also be accepted.

Although, the preferred signal levels for interface, grooming, and cross-connection are listed above, those skilled in the art are aware that other choices would be operational. The present invention is not restricted to these listed levels, but they are given as preferred and operational levels. The DCS connection provided by these devices is capable of processing signals transmitted between rings. This processing may occur at different signal levels. The DCS connection also provides local access. In this way, connectivity is provided between the ring terminals of different rings, and to local sources. The DCS connection formed may be any device or combination of devices with the above capabilities. For purposes of redundancy, additional back-up DCS connection capability can be added at a node.

Other connections are also operational in the context of the present invention. In one embodiment, direct cabling at OC-N or STS-N could be used to connect ring terminals on different rings. In another embodiment, an ATM switch with

the DCS functionality described could be used to connect the ring terminals of different rings.

At present, SONET standards are driving the choice of OC-12 transmission. This causes a problem since there are no devices currently available that accept, groom, and connect OC-12 traffic between SONET rings. This is another reason that networks have opted for a DCS based architecture. The DCS architecture does not require an OC-12 interface between rings which is currently unavailable. The present invention solves the problem of ring connectivity at OC-12 with the DCS connection.

As stated above, ring architectures solve the problem of excessive survivability time because they can be designed to be self-healing. At present, the benefit of self-healing rings is outweighed in the large network environment because of the impractical overbuild and connectivity problems. However, by stacking rings, and using a DCS connection between rings, the present invention overcomes these problems. As a result, self-healing ring technology can be employed in the present invention to provide significantly improved survivability features.

There are three basic types of self-healing ring methods: path switched unidirectional, line switched two fiber bidirectional, and line switched four fiber bidirectional. Line switched four fiber bidirectional is preferred. These formats for self-healing rings are known in the art, but they have yet to be applied within the large network environment because of the above stated problems with rings in networks larger than LATAs or metropolitan areas. The present invention employs self-healing capability in particular ring terminals on each ring. Problems are avoided by routing the traffic around the operational side of the ring to the destination.

As a result, the present invention provides a SONET system that employs self-healing rings which can efficiently span large geographic distances. Although it is preferred to minimize the size of rings, large rings are inherent to the large network environment. An IXC is an example of a large network, but in the present invention, a network which encompasses an area larger than a LATA or a metropolitan area is considered a relatively large network. Traffic can thus be transmitted from LATA to LATA, or metropolitan area to metropolitan area and maintain millisecond survivability. Current DCS based SONET architectures cannot provide this performance in the large network environment. Current SONET ring architectures are restricted to use in small geographic areas, such as LATAs and metropolitan areas, or to single large rings. By featuring stacked self-healing SONET rings with DCS connections, the present invention eliminates these current problems.

What is claimed is:

1. A Synchronous Optical Network (SONET) system comprising:

a first node configured to groom SONET traffic and comprising a first ring terminal and a second ring terminal;

a third ring terminal connected to the first ring terminal to form a first SONET ring wherein the first SONET ring comprises first ring spans connecting the first ring terminal and the third ring terminal; and

a fourth ring terminal connected to the second ring terminal to form a second SONET ring wherein the second SONET ring comprises second ring spans connecting the first ring terminal and the third ring terminal and wherein a first portion of the first ring spans and a second portion of the second ring spans share a physical route.

2. The SONET system of claim **1** wherein the first node is further configured to groom the SONET traffic at a Synchronous Transport Signal (STS) and a Virtual Tributary (VT) level.

3. The SONET system of claim **1** wherein the first node is further configured to groom the SONET traffic at a DS**0** level.

4. The SONET system of claim **1** wherein the first node is further configured to provide access to the first SONET ring and to the second SONET ring.

5. The SONET system of claim **1** wherein the first node is further configured to switch the SONET traffic.

6. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM).

7. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are configured to use Wave Division Multiplexing (WDM) to separate the first ring spans of the first SONET ring from the second ring spans of the second SONET ring.

8. The SONET system of claim **1** wherein the first SONET ring and the second SONET rings are comprised of four optical fibers.

9. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring have a work line and a protect line in separate optical fibers.

10. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are self healing.

11. The SONET system of claim **1** wherein the first SONET ring and the second SONET ring are line switched.

12. The SONET system of claim **1** wherein the first SONET ring comprises a plurality of other ring terminals.

13. The SONET system of claim **1** wherein the second SONET ring comprises a plurality of other ring terminals.

14. The SONET system of claim **1** further comprising another node connected to the first SONET ring and the second SONET ring and configured to groom the SONET traffic.

15. The SONET system of claim **14** wherein the other node is further configured to groom the SONET traffic at a Synchronous Transport Signal (STS) level and the Virtual Tributary (VT) level.

16. The SONET system of claim **14** wherein the other node is further configured to groom the SONET traffic at the DS**0** level.

17. The SONET system of claim **14** wherein the other node is further configured to provide access to the first SONET ring and to the second SONET ring.

18. The SONET system of claim **14** wherein the other node is further configured to switch the SONET traffic.

* * * * *

EXHIBIT D

US006870832B1

(12) **United States Patent**
Bog et al.

(10) **Patent No.: US 6,870,832 B1**
(45) **Date of Patent: Mar. 22, 2005**

(54) **TELECOMMUNICATIONS PROVIDER AGENT**

(75) Inventors: **Abdullah Murat Bog**, Milpitas, CA (US); **Steven Turner**, Overland Park, KS (US); **Matthew Kung-Wei Jonathan Barrow**, Kansas City, MO (US); **Tracey Mark Bernath**, Leawood, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 909 days.

(21) Appl. No.: **09/803,842**

(22) Filed: **Mar. 12, 2001**

Related U.S. Application Data

(63) Continuation of application No. 09/128,944, filed on Aug. 5, 1998, now Pat. No. 6,229,803.

(51) **Int. Cl.**[7] **H04L 12/66**
(52) **U.S. Cl.** **370/353**; 379/166
(58) **Field of Search** 370/352–358, 370/401, 395, 398, 494, 495, 493, 463, 431; 379/93.09, 142.13, 166, 167.13; 709/200, 202, 204, 213, 227, 230, 311, 320

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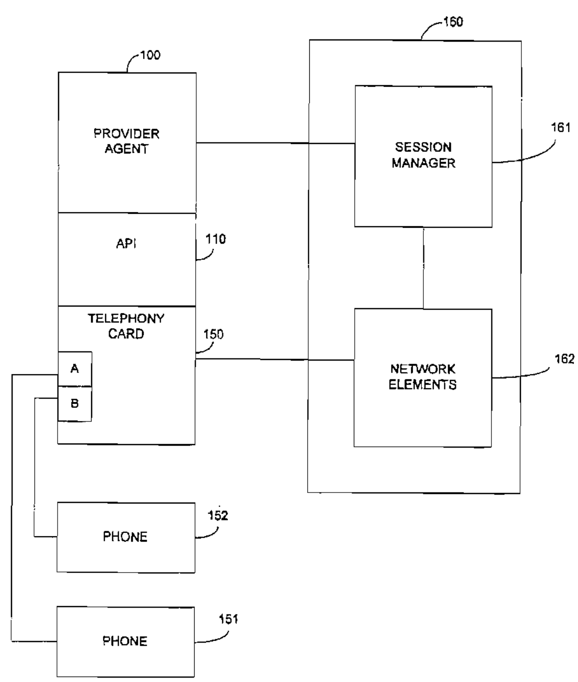
Primary Examiner—Wellington Chin
Assistant Examiner—Brenda Pham

(57) **ABSTRACT**

The invention is a provider agent product and method that operates as a software interface between a telephony card and a session manager in an advanced communications network. The provider agent receives event messages from the telephony card indicating on-hook events, off-hook events, and digit events. The provider agent instructs the telephony card to provide dial tone, ring current, ringback, and busy signals to the telephones. The provider agent also exchanges messages with a session manager in the network. These messages include: invite messages, reply messages, join messages, and terminate messages. In response to the above processing, the provider agent instructs the telephony card to interwork telephony signals on a telephony channel with ATM signals on an ATM virtual channel. The provider agent is comprised of a plurality of software objects that are stored on a software storage medium and that include: a controller object, port objects, and event objects. The provider agent objects are executed by a multithreaded processing system and each object has a separate processing thread. The provider agent and the telephony card communicate through an application programming interface that is specified in an Interface Definition Language (IDL) of a Common Object Request Broker Architecture (CORBA).

24 Claims, 7 Drawing Sheets



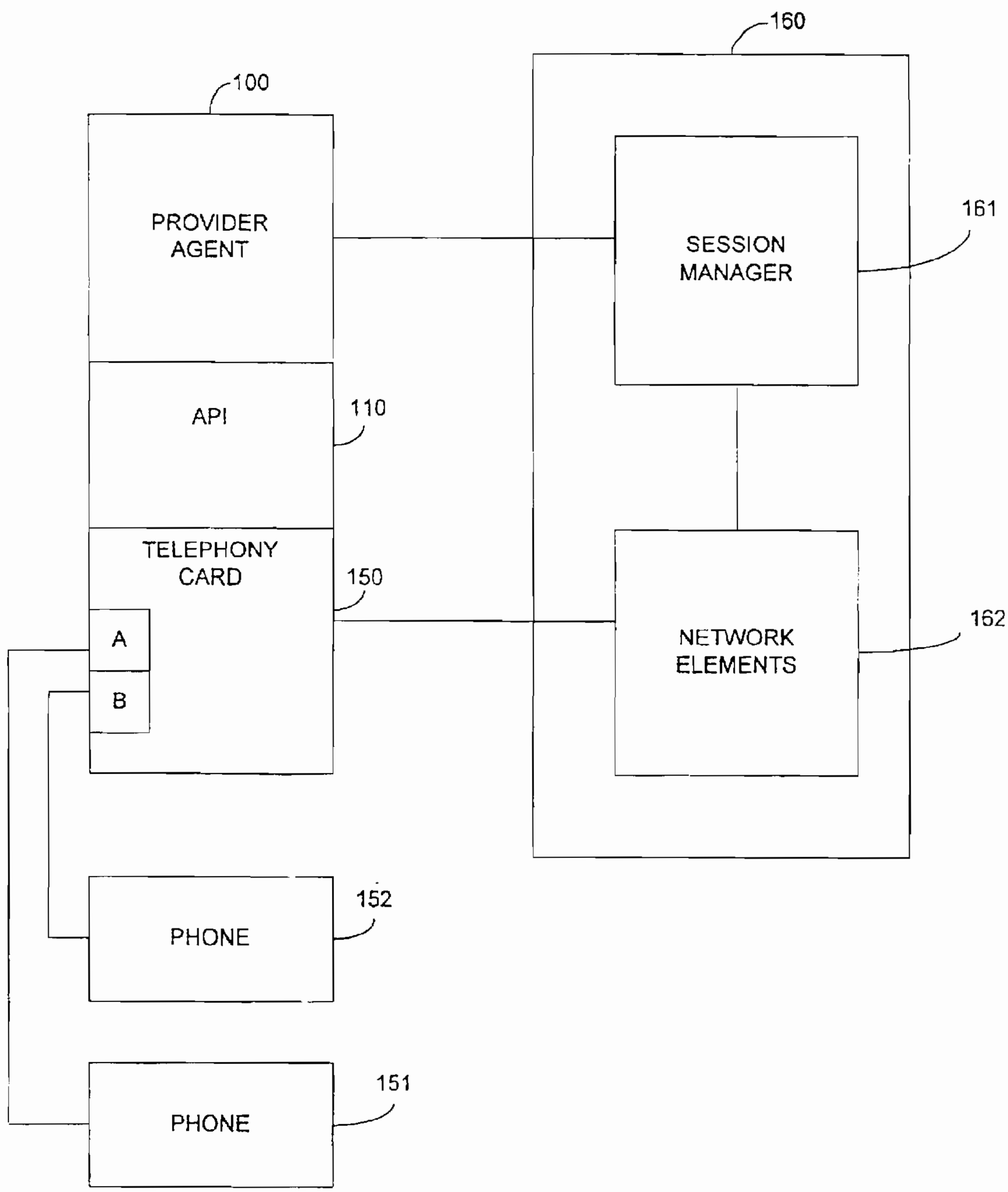
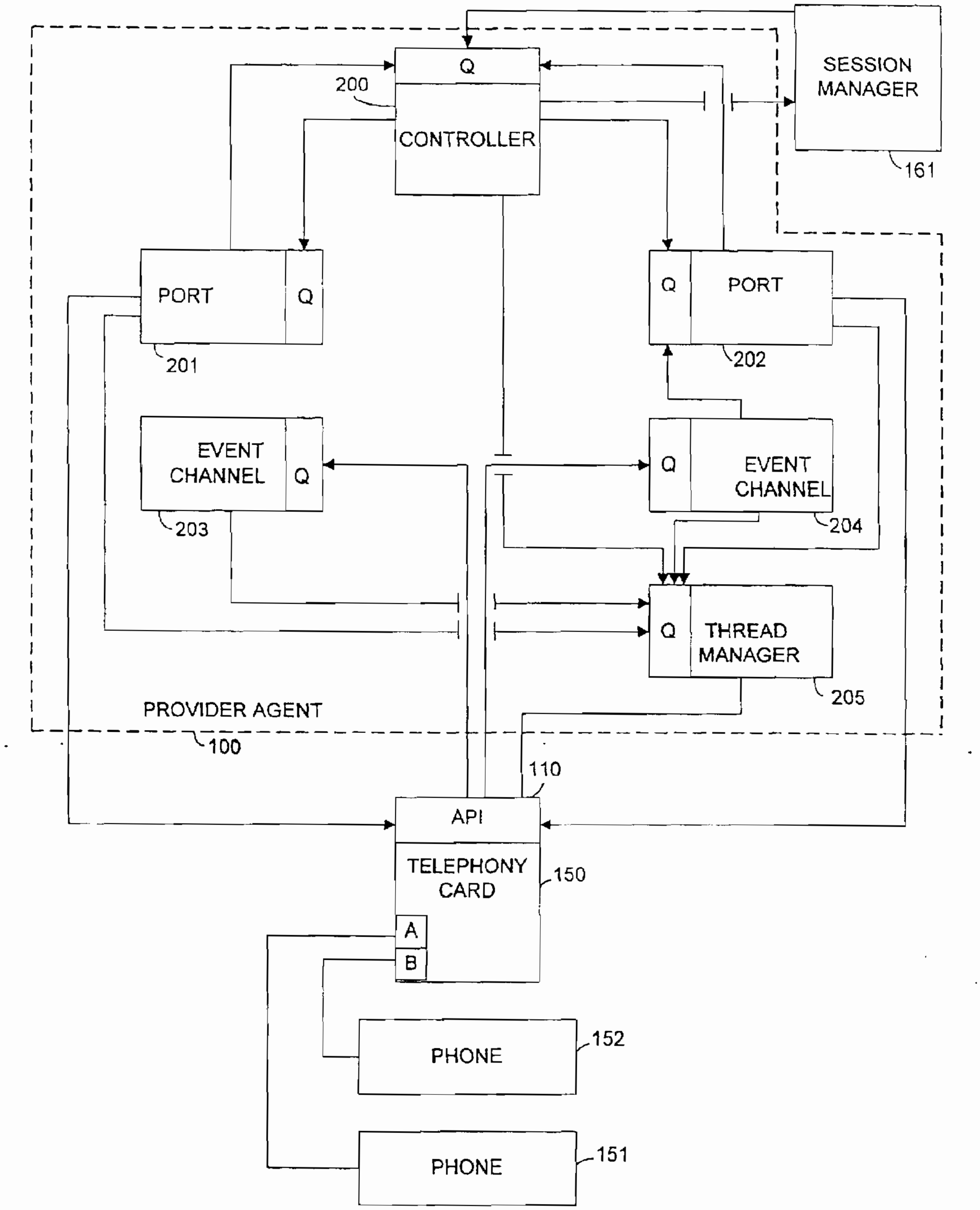

160
100
PROVIDER AGENT
SESSION MANAGER
161
API
110
TELEPHONY CARD
150
A
B
NETWORK ELEMENTS
162
PHONE
152
PHONE
151

FIG. 1



SESSION MANAGER
161
Q
200
CONTROLLER
PORT
Q
201
Q
PORT
202
EVENT CHANNEL
Q
203
Q
EVENT CHANNEL
204
Q
THREAD MANAGER
205
PROVIDER AGENT
100
110
API
TELEPHONY CARD
150
A
B
PHONE
152
PHONE
151

FIG. 2

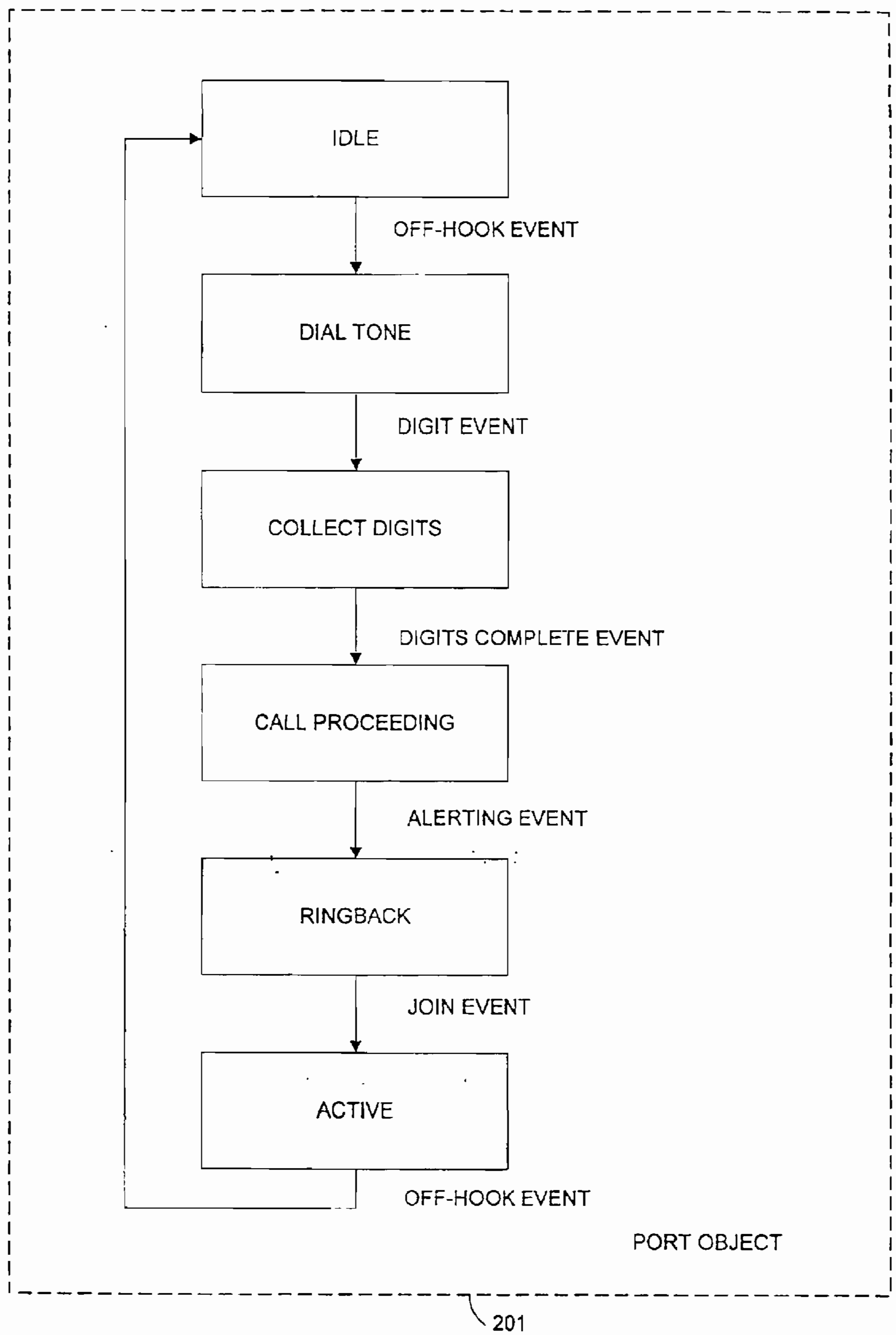
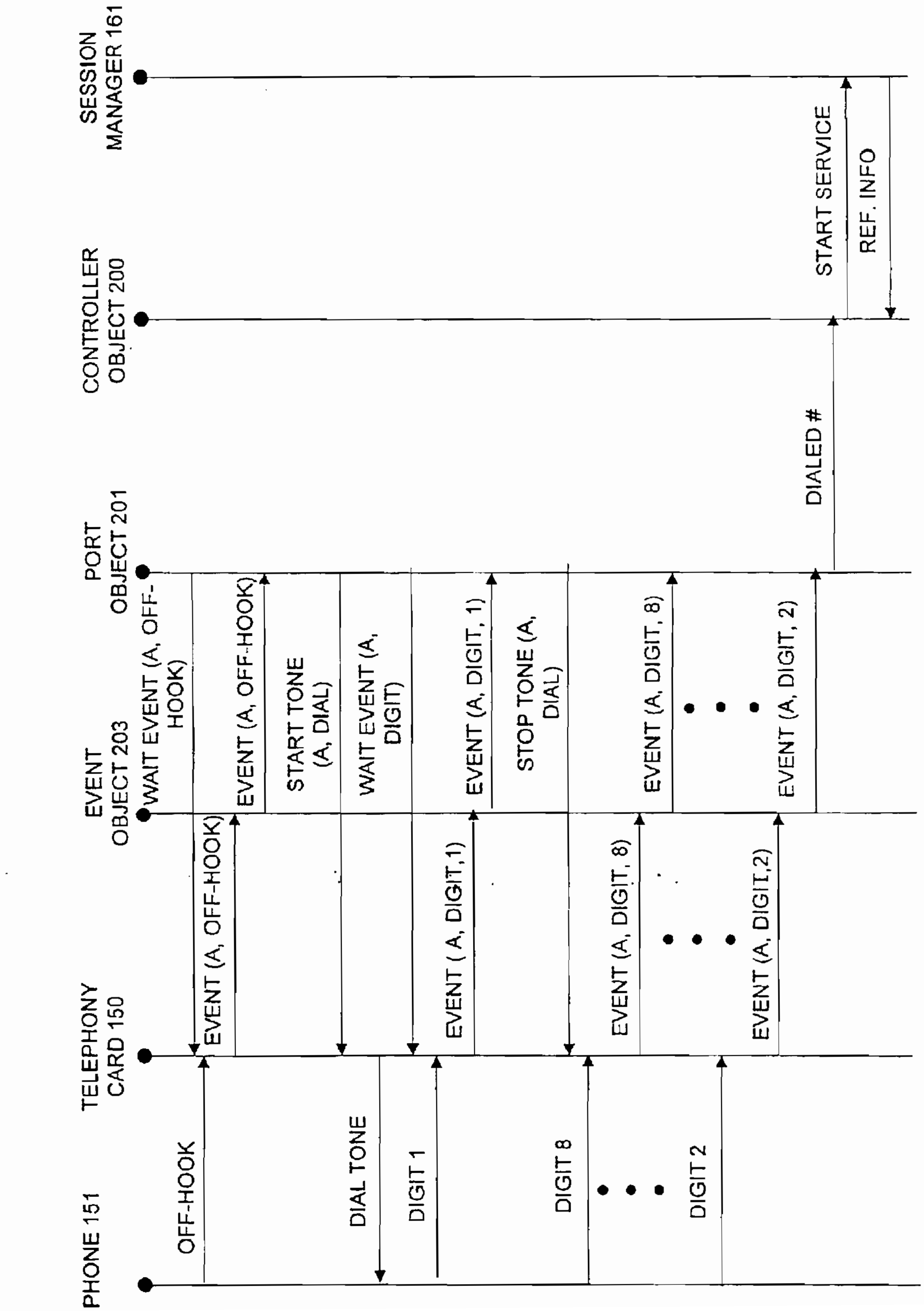

IDLE
OFF-HOOK EVENT
DIAL TONE
DIGIT EVENT
COLLECT DIGITS
DIGITS COMPLETE EVENT
CALL PROCEEDING
ALERTING EVENT
RINGBACK
JOIN EVENT
ACTIVE
OFF-HOOK EVENT
PORT OBJECT
201

FIG. 3



SESSION MANAGER 161
CONTROLLER OBJECT 200
PORT OBJECT 201
EVENT OBJECT 203
TELEPHONY CARD 150
PHONE 151
START SERVICE
REF. INFO
DIALED #
WAIT EVENT (A, OFF-HOOK)
EVENT (A, OFF-HOOK)
START TONE (A, DIAL)
WAIT EVENT (A, DIGIT)
EVENT (A, DIGIT, 1)
STOP TONE (A, DIAL)
EVENT (A, DIGIT, 8)
EVENT (A, DIGIT, 2)
EVENT (A, OFF-HOOK)
EVENT (A, DIGIT,1)
EVENT (A, DIGIT, 8)
EVENT (A, DIGIT,2)
OFF-HOOK
DIAL TONE
DIGIT 1
DIGIT 8
DIGIT 2

FIG. 4

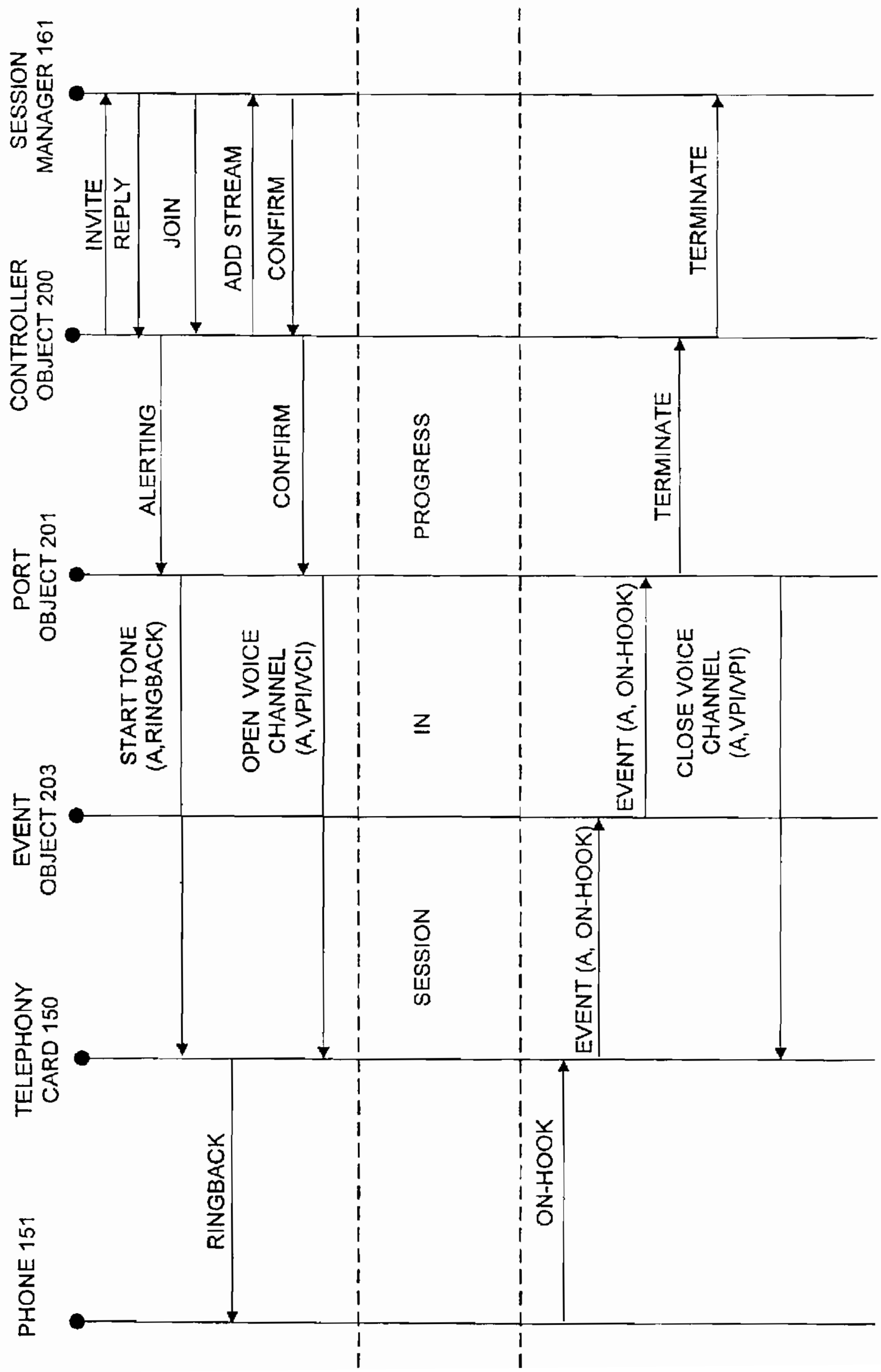

SESSION MANAGER 161
CONTROLLER OBJECT 200
PORT OBJECT 201
EVENT OBJECT 203
TELEPHONY CARD 150
PHONE 151
INVITE
REPLY
JOIN
ADD STREAM
CONFIRM
TERMINATE
ALERTING
CONFIRM
PROGRESS
TERMINATE
START TONE (A,RINGBACK)
OPEN VOICE CHANNEL (A,VPI/VCI)
IN
EVENT (A, ON-HOOK)
CLOSE VOICE CHANNEL (A,VPI/VPI)
SESSION
EVENT (A, ON-HOOK)
RINGBACK
ON-HOOK

FIG. 5

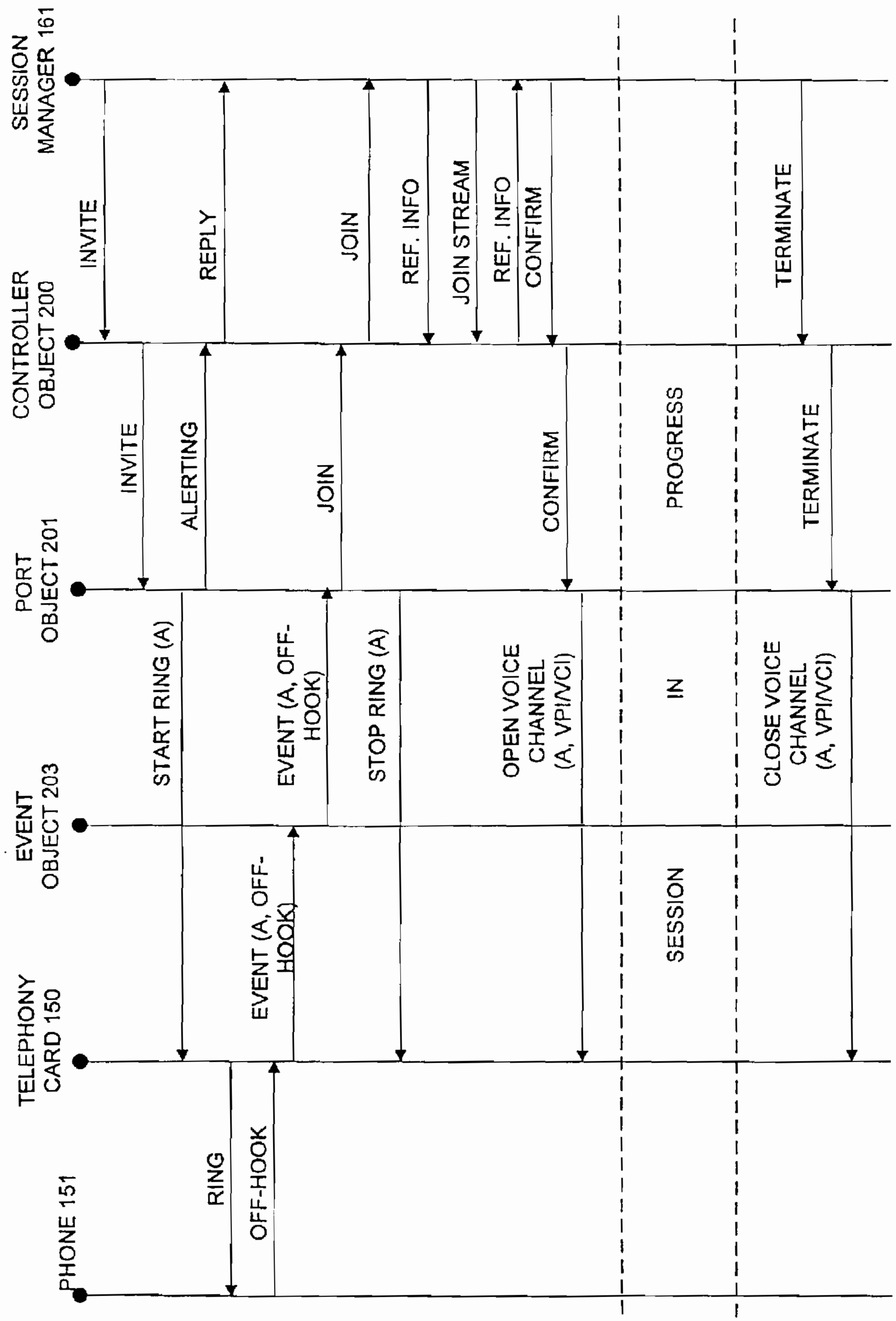

SESSION MANAGER 161
CONTROLLER OBJECT 200
PORT OBJECT 201
EVENT OBJECT 203
TELEPHONY CARD 150
PHONE 151
INVITE
REPLY
JOIN
REF. INFO
JOIN STREAM
REF. INFO
CONFIRM
TERMINATE
INVITE
ALERTING
JOIN
CONFIRM
PROGRESS
TERMINATE
START RING (A)
EVENT (A, OFF-HOOK)
STOP RING (A)
OPEN VOICE CHANNEL (A, VPI/VCI)
IN
CLOSE VOICE CHANNEL (A, VPI/VCI)
EVENT (A, OFF-HOOK)
SESSION
RING
OFF-HOOK

FIG. 6

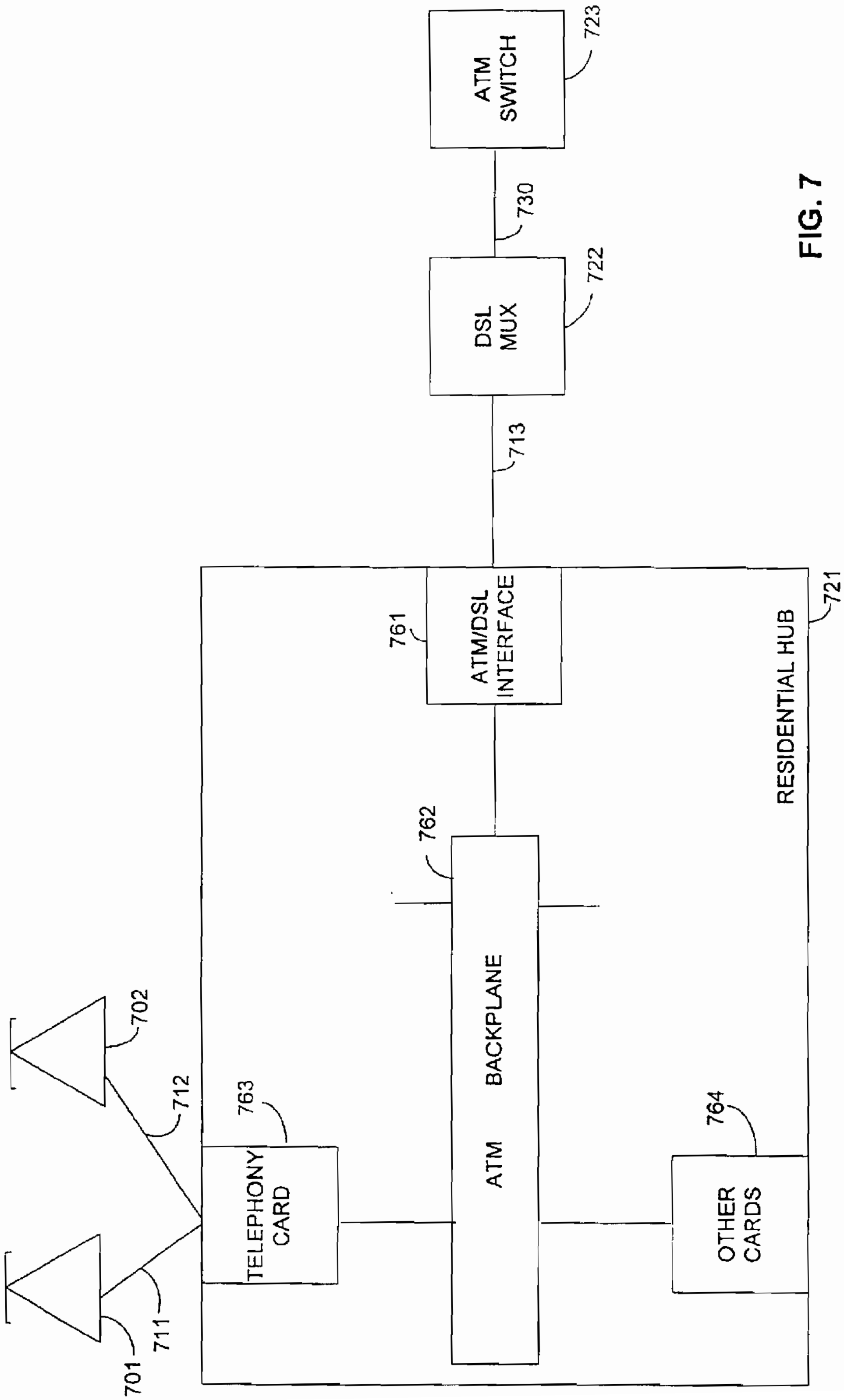

ATM SWITCH
723
730
DSL MUX
722
713
ATM/DSL INTERFACE
761
721
RESIDENTIAL HUB
762
ATM BACKPLANE
702
712
763
TELEPHONY CARD
764
OTHER CARDS
701
711

FIG. 7

TELECOMMUNICATIONS PROVIDER AGENT

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 09/128,944, filed Aug. 5, 1998, now Pat. No. Appl. 6,229, 803 and which is incorporated by reference into this application.

FIELD OF THE INVENTION

The invention is related to the field of telecommunications, and in particular, to a software interface product and method utilized between a telephony card and a digital communications network.

BACKGROUND

Advanced communications networks are being developed to support a vast array of communications services. These networks are controlled by complex hardware and software platforms referred to as session managers. Users requiring communications sessions from these advanced networks must interface with the session managers to, request and receive communications services. Session managers operate using various messages, such as invite messages, reply messages, confirm messages, join messages, and terminate messages.

A class 5 telephone switch communicates with an analog telephone using the analog telephony signals in the well-known analog telephony format. The class 5 telephone switch provides power to the telephone. The class 5 telephone switch detects off-hook current caused by the telephone and provides the telephone with dial tone. The caller generates Dual-Tone Multi-Frequency (DTMF) signals. The class 5 telephone switch detects the DTMF signals and initiates the call in the network. When the far-end telephone is ringing, the class 5 telephone switch plays a ringback tone to the caller. If the far-end telephone is busy, the class 5 telephone switch plays a busy tone to the caller. On incoming calls, the class 5 telephone switch provides ring current to the telephone.

Telephony cards are being developed to manage multiple telephones in the home. The telephony cards are typically plugged into communications hubs or computers in the residence, and telephones are connected to the telephony card. The telephony cards connect these telephones in the home to a network element in the advanced communications network. This connection between the telephony card and the network element is much different than the traditional analog line to the local switch. This connection is typically an Asynchronous Transfer Mode (ATM) connection to an ATM device. ATM signals do not traditionally support analog telephony signals, such as off-hook, dial tone, and busy signals. The telephony cards detect off-hook conditions, on-hook conditions, and digits. In addition, the telephony cards provide the telephones with dial tone, ring current, ringback, and busy signals.

At present, there is not an acceptable software interface method or product for use between the telephony card and the session manager in the network. There is a need for software that can provide an interface between the telephony card and the session manager.

SUMMARY

The invention overcomes these problems with a provider agent that operates as a software interface between the

telephony card and the session manager. The provider agent allows users to obtain conventional telephone service from an advanced broadband network. The provider agent is comprised of software objects that are stored on a software storage medium.

In some embodiments, the provider agent is comprised of a plurality of objects including a controller object, port objects, and event objects. The provider agent is executed by a multithreaded processing system and these objects each have a separate processing thread. The provider agent and the telephony card communicate through an Application Programming Interface (API). In some embodiments, the API is specified in the Interface Definition Language (IDL) of the Common Object Request Broker Architecture (CORBA)

The invention includes a provider agent software interface for use between a telephony card and a session manager. The telephony card is operational to interwork between analog telephony signals over a plurality of telephony channels and ATM signals over a plurality of ATM virtual connections in response to interwork instructions. The telephony card is operational to detect on-hook events, off-hook events, and digit events and to provide event messages. The telephony card is operational to provide dial tone, ringback, and busy signals in response to tone instructions. The session manager is operational to transmit and receive invite messages, reply messages, join messages, and terminate messages.

The provider agent receives an off-hook event message for a first channel from the telephony card, and in response, transmits a dial tone instruction for the first channel to the telephony card. The provider agent receives a plurality of digit event messages for the first channel from the telephony card, and in response, transmits an invite message indicating a dialed number for the first channel to the session manager. The provider agent receives a reply message for the first channel from the session manager indicating an alerting condition, and in response, transmits a ringback tone instruction for the first channel to the telephony card. The provider agent receives a join message for the first channel from the session manager, and in response, transmits an add stream message for the first channel to the session manager. The provider agent receives a confirm message for the first channel from the session manager, and in response, transmits a first interwork instruction for the first channel to the telephony card to interwork a telephony signal on the first channel with an ATM signal on a selected virtual channel for the first channel.

In some embodiments of the invention, the provider agent receives an on-hook event message for the first channel from the telephony card, and in response, transmits a terminate message for the first channel to the session manager and transmits a second interwork instruction for the first channel to the telephony card to stop interworking the first channel and the selected virtual channel. In other embodiments, the provider agent receives a termination message for the first channel from the session manager, and in response, transmits a second interwork instruction for the first channel to the telephony card to stop interworking the first channel and the selected virtual channel.

In some embodiments of the invention, the provider agent receives an off-hook event message for a second channel from the telephony card, and in response, transmits a dial tone instruction for the second channel to the telephony card. The provider agent receives a plurality of digit event messages for the second channel from the telephony card, and in response, transmits an invite message for the second channel to the session manager. The provider agent receives a reply message for the second channel from the session manager indicating an alerting condition, and in response, transmits a ringback tone instruction for the second channel to the telephony card. The provider agent receives a join message for the second channel from the session manager, and in response, transmits an add stream message for the second channel to the session manager. The provider agent receives a confirm message for the second channel from the session manager, and in response, transmits a second interwork instruction for the second channel to the telephony card to interwork a telephony signal on the second channel with an ATM signal on a selected virtual channel for the second channel.

In some embodiments of the invention, the provider agent receives an invite message for a second channel from the session manager, and in response, transmits a ring instruction for the second channel to the telephony card and transmits a reply message indicating an alerting condition for the second channel to the session manager. The provider agent receives an off-hook event message for the second channel from the telephony card, and in response, transmits a join message for the second channel to the session manager. The provider agent receives a join stream message for the second channel from the session manager, and in response, transmits a reference information message for the second channel to the session manager. The provider agent receives a confirm message for the second channel from the session manager, and in response, transmits a second interwork instruction for the second channel to the telephony card to interwork a telephony signal on the second channel with an ATM signal on a selected virtual channel for the second channel.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a system architecture in some examples of the invention.

FIG. **2** is a block diagram of a software architecture in some examples of the invention.

FIG. **3** is a port object state machine diagram for some examples of the invention.

FIGS. **4**–**6** are message sequence charts for some examples of the invention.

FIG. **7** is a block diagram of a residential hub for some examples of the invention.

DETAILED DESCRIPTION

System Architecture—FIG. **1**

FIG. **1** depicts one example of a system architecture in block diagram form. A provider agent **100** is coupled to an Application Programming Interface (API) **110**. The API **110** is coupled to a telephony card **150**. The telephony card **150** is connected to phones **151**–**152** over channels A and B respectively. The provider agent **100** is coupled with a session manager **161** in a network **160**. The telephony card **150** is connected to network elements **162** in the network **160**.

The network **160** is comprised of network elements **162** that provide digital communications services to the telephony card **150**. Some examples of network elements **162** are ATM switches and multiplexers, Digital Subscriber Line (DSL) equipment, Internet Protocol (IP) routers and servers, and enhanced services platforms. The session manager **161** controls the set-up and delivery of communications services in the network **160**. The session manager **161** receives user service requests and invokes the desired services through network elements **162**.

Version 0.8 of the "Retailer Reference Point Specification" issued by the Telecommunication Information Network Architecture Consortium (TINA-C) specifies the session manager **161** and the connection and messaging between the session manager **161** and the provider agent **100**. The interface between the session manager **161** and the provider agent **100** is compiled into CORBA IDL. The interface transport is via Transaction Control Protocol/Internet Protocol (TCP/IP) using Logic Link Control/Sub-Network Access Protocol (LLC/SNAP) encapsulation and ATM Adaptation Layer 5 (AAL5) to provide Permanent Virtual Connection (PVC) connectivity.

The telephony card **150** includes channels for the phones **151**–**152** and an interface to the network **160**. In some embodiments of the invention, the channels to the phones **151**–**152** are conventional telephone ports, and the interface to the network **160** is an ADSL/ATM port. The telephony card **150** includes circuitry to interwork analog telephony signals from the phones **151**–**152** with the digital signals to the network **160**. One example of such a digital signal is an ADSL/ATM signal. The telephony card **150** includes circuitry that generates dial tones, ring-back tones, busy tones, fast-busy tones, and ring current for the phones **150**–**151**. The telephony card **150** includes circuitry that detects Dual Tone Multi-Frequency (DTMF) digit events, off-hook events, and on-hook events, and that provides messages indicating these events. The telephony card **150** also includes software control systems that control the circuitry and interface with the API **110**. One example of the telephony card **150** is the telephony card product provided by InnoMedia Logic (IML) of Quebec, Canada.

The phones **151**–**152** represent any communications devices supported by the telephony card **150**. Some examples are conventional analog telephones, wireless phones, computers, modems, and fax machines. Additional phones could be connected to channels A and B, or additional phones could be connected to additional channels on the telephony card **150**. Only two channels with one phone each is shown for the sake of clarity.

Those skilled in the art are familiar with the telephony card **150** and the network **160**. A description of these elements is found in co-pending U.S. patent application Ser. No. 08/826,641, entitled "Telecommunications System", filed on April 7, 1997, assigned to the same entity as this patent application, and that is hereby incorporated by reference into this patent application. A description of these elements is found in co-pending United States patent application entitled "Asynchronous Transfer Mode System for Providing Telephony Service", filed on the same date as this patent application, assigned to the same entity as this patent application, and that is hereby incorporated by reference into this patent application.

The API **110** is a software interface that exchanges event messages and instructions between the telephony card **150** and the provider agent **100**. The provider agent **100** accepts event messages from the telephony card **150** through the API **110** and provides instructions back to the telephony card **150**. For example, the provider agent **100** might receive information through the API **110** that the phone **151** has gone off-hook. In response, the provider agent **100** might provide a control instruction through the API **110** to the telephony card **150** to provide dial tone to the phone **151**. In some embodiments of the invention, the API **110** is specified in CORBA IDL.

The provider agent **100** responds to event messages for the phones **151**–**152** with instructions for the telephony card **150** to interact with the user. User interaction includes dial tone, digit collection, ring, ringback, and busy signals. The provider agent **100** also exchanges messaging with the session manager **161**. Messages include invite messages, reply messages, join messages, confirm messages, and terminate messages.

Both the provider agent **100** and the API **110** are comprised of software that is stored on a software storage medium. Examples of a software storage medium include magnetic disks, optical disks, or integrated circuits. The provider agent **100** and the API **110** could also be stored on a server and down-loaded to a user over the Internet or another operational connection. Both the provider agent **100** and the API **110** are executed by a microprocessor system. The microprocessor system could be comprised of a single microprocessor or a configuration of related microprocessors. The microprocessor system could be housed in many devices with a few examples being a residential communications hub, a computer, or the telephony card **150**. In some embodiments of the invention, the provider agent is comprised of objects written in C++ code.

Software Architecture—FIGS. **2–3**

FIG. **2** depicts one example of a software architecture for the provider agent **100**. The provider agent **100**, the API **110**, the telephony card **150**, the phones **151–152**, and session manager **161** are shown as in FIG. **1** and operate as discussed above. The provider agent **100** is comprised of the following software objects: a controller object **200**, port objects **201–202**, event objects **203–204**, and a thread manager object **205**. The port object **201** and the event object **203** are associated with channel A. The port object **202** and the event object **204** are associated with channel B. The software objects **200–205** are executed by a multi-threaded processing system with each object having its own thread. Each object also has a queue that is indicated on FIG. **2** by the letter "Q". The queue is the software component that receives and buffers messages for the object.

The controller object **200** communicates with the session manager **161** and the port objects **201–202**. Communications with the session manager **161** are comprised of the following messages:

- Start Service—a message to the session manager that initially identifies the service requested and includes an access key, a service ID, and user information.
- Reference Information—a message from the session manager that includes session ID, party ID, and a secret ID.
- Invite—a message that requests a telephony session and includes the dialed number(s).
- Reply—a message that responds to an Invite message and indicates alerting, busy, or reject.
- Join—a message that indicates that the party is ready to join the session.
- Add Stream—a message to the session manager that requests a connection to be established to another party and that includes the terminal ID, the Party ID and the Virtual Path (VP)/Virtual Connection (VC).
- Join Stream—a message from the session manager that requests a party to attach to a connection from another party.
- Confirm—a message that is sent or received by the provider agent and that indicates that an ATM network connection has been made.
- Terminate—a message that is sent or received by the provider agent and that indicates that the session is over.

The controller object **200** encapsulates call related information by generating call record objects that are identified

by session ID and channel ID. The controller object **200** stores data indicating the idle or busy status of each channel. The controller object **200** includes an internal data structure for any desired call-handling policies. Call handling policies include rules for call waiting, voice mail, call blocking, and the internal routing of incoming calls to particular phones, such as idle phones. These policies can be varied based on the caller's number, the time of day, or other factors.

The port objects **201–202** are state machines. FIG. **3** depicts one example of a state machine for the port object **201** in block diagram form. The initial state is Idle. An off-hook event for channel A moves the port object **201** to the dial tone state and an instruction to provide dial tone is provided to the telephony card **150**. A digit event for channel A moves the port object **201** to the collect digits state and an instruction to stop dial tone is provided to the telephony card **150**. The port object **201** creates a digit collection object. Digits that are collected by the telephony card **150** are provided to the digit collection object for analysis. The digit collection object determines the type of number dialed, such as emergency numbers, seven-digit numbers, ten-digit numbers, and international numbers. The digit collection object instructs the port object **201** when digit collection is complete. A digits complete event for channel A moves the port object **201** to the call proceeding state and the port object **201** instructs the controller object **200** to send Start Service and Invite messages to the session manager **161**. An alerting indication from the controller object **200** moves the port object **201** to the ringback state where a ringback instruction is provided to the telephony card. The alerting event is based on a reply message from the session manager **161**. A join event from the controller object **200** moves the port object **201** to the active state where the session is conducted. The join event is based on a join message from the session manager **161**. An on-hook event for channel A moves the port object **201** back to the idle state and results in a termination message being sent by the controller object **200** to the session manager **161**.

A few deviations from the above-described state machine should be appreciated. If the reply message had a busy indication, a busy state would be entered instead of the ringback state, and a busy tone instruction would be provided to the telephony card **150**. If the reply message had a reject indication, a fast-busy state would be entered instead of the ringback state and a fast-busy tone instruction would be provided to the telephony card **150**. In both of the above cases, an on-hook event moves the port object **201** back to the idle state.

When receiving a call, the state machine is much simpler. In the idle state, an invite indication from the controller object **200** moves the port object **201** to the ring state where the telephony card is instructed to ring channel A. The invite indication is based on an invite message from the session manager **161**. An off-hook event for channel A moves the port object **201** to that active state, until an on-hook event moves the port object **201** back to the idle state.

Referring back to FIG. **2**, the event objects **203–204** track the events for each respective channel and indicate the events to the respective port objects **201–202**. The event object **203** can process events using a different thread than the port object **201**, and the event object **204** can process events using a different thread than the port object **202**. Multi-threaded processing in this manner has advantages. Multi-threading simplifies system design and is more efficient than a single-threaded system. Multi-threading allows multiple threads to be processed in various states at the same time without the entire system waiting for a single input.

The API **110** utilizes a messaging format comprised of an instruction followed by variables in parentheses. The primary instructions are:

start ring (channel ID)
stop ring (channel ID)
start tone (channel ID, tone type)
stop tone (channel ID, tone type)
wait event (channel ID, event type)
event (channel ID, event type, value)
open voice channel (channel ID, VPI/VCI)
close voice channel (channel ID, VPI/VCI)

In the above messages, the channel ID identifies the relevant channel of the telephony card **150**. The tone types are dial tone, ringback, busy, and fast-busy. The event types are off-hook, on-hook, and digit. The value is the value of the digit. The VPI/VCI identifies the Virtual Path and Virtual Channel used by the telephony card **150** for the session.

The thread manager object **205** provides fault tolerance for software failures and certain hardware failures. The thread manager object **205** continuously receives heartbeat messages from the objects **200–204**. If a heartbeat message is not received as expected, the thread manager object **205** identifies and attempts to restart the affected thread. If the heartbeat is still absent, the thread manager object **205** instructs the telephony card **150** to use conventional failover analog telephone service for the channel with the malfunctioning thread.

System Operation—FIGS. **4–6**

FIGS. **4–6** depict a message sequence chart for operative examples of the invention, but the invention is not restricted to these examples. FIGS. **4** and **5** depict a call that originates and terminates at the phone **151**. On FIG. **4**, the port object **201** sends "wait event (A, off-hook)" to the telephony card **150**. When the user places a call by taking the phone **151** off-hook, the telephony card **150** detects the off-hook event and transmits "event (A, off-hook)" to the event object **203**. Messages between the telephony card **150** and the event object **203** or the port object **201** utilize the API **110**. The event object **203** provides an off-hook indication to the port object **201**. The port object **201** moves from the idle state to the dial tone state and responds to the telephony card **150** with the messages "start tone (A, dial)" and "wait event (A, digit)". The port object **201** also generates an instance of a digit collection object to process subsequently collected digits.

The user inputs a called number using the telephone **151**. The telephony card **150** detects the digits and forwards the values to the event object **203**. For a called number of 1-800-555-2222, the messages "event (A, digit, 1)" and "event (A, digit, 8)" would be used for the first two dialed digits, and the message "event (A, digit, 2)" would be used for the last dialed digit. The event object **203** provides a digit indication to the port object **201**. After the first digit, the port object **201** moves from the dial tone state to the digits state and sends "stop tone (A, dial)" to the telephony card **150**. In response, the telephony card **150** stops the dial tone on channel A. The port object **201** also processes the digit values with the digit collection object.

The digit collection object determines that the formatting of the called number is correct and that digit collection is complete. The digit collection object indicates to the port object **201** that digit collection is complete and provides the called number. In response to the digits complete message, the port object **201** moves from the digits state to the call proceeding state and indicates a request for telephony service with the dialed number to the controller object **200**.

The controller object **200** generates and transmits a Start Service message requesting telephone service to the session manager **161**. The session manager responds with reference information such as the session ID, the party ID, and a secret ID. On FIG. **5**, the controller object **200** generates and transmits an invite message with the dialed number to the session manager **161**. The session manager **161** typically sets-up the session and returns a reply message to the controller object **200** indicating that the called party is being alerted. Alternatively, the called party might be busy or might reject the session.

If an alerting indication is received in the reply message, the controller object **200** indicates the alerting condition to the port object **201**, and the port object moves to the ringback state. The port object **201** sends "start tone (A, ringback) to the telephony card **150**. In response, the telephony card **150** puts a ringback tone on channel A to emulate a ringing phone at the far end.

When the party at the far end accepts the invitation, the session manager **161** sends a Join message to the controller object **200**. In response, the controller object; **200** generates and transmits an add stream message to the session manager **161** with the terminal ID, the party ID, and the VPI/VCI. The session manager **161** sends a Confirm message to the controller object **200** and the controller object **200** sends a confirm indication to the port object **201**. In response to the confirm indication, the port object **201** sends "open voice channel (A, VPI/VCI)" to the telephony card **150**. In response to the open voice channel message, the telephony card **150** stops the ringback tone and interworks the analog telephony signal on channel A with the ATM signal on the VPI/VCI. At this point, the session is in progress and the telephone call can proceed.

The session ends when the user places the phone **151** on-hook. The telephony card **150** sends "event (A, on-hook)" to the event object **203** which indicates the on-hook to the port object **201**. The port object **201** indicates the termination status to the controller object **200** and sends "close voice channel (A, VPI/VCI)" to the telephony card **150**. The telephony card **150** ceases to interwork channel A with the VPI/VCI. The controller object **200** generates and transmits a Terminate message to the session manager **161**.

FIG. **6** depicts a call that is placed to the phone **151** by another party and that is terminated by the other party. The controller object **200** first receives an Invite message with a session ID and dialed number from the session manager **161**. The controller object **200**, based on its call-handling policy, determines which phone to route the call to. In this example, the call is routed to channel A. The controller object **200** indicates the invitation to the port object **201**, and the port object **201** sends "start ring (A)" to the telephony card **150**. The telephony card begins to ring the phone **151**. The controller object **200** sends a reply message back to the session manager **161** indicating that the user is being alerted. In the alternative, the reply message sent to the session manager **161** could indicate that the phone **151** was busy or that the session was rejected.

When the user takes the phone **151** off-hook to answer the call, the telephony card **150** sends event (A, off-hook)" to the event object **203** which indicates the off-hook to the port object **201**. The port object **201** sends "stop ring (A)" to the telephony card **150** which stops the ringing. The port object **201** informs the controller object **200** that the user has joined the session and the controller object **200** sends a join message to the session manager **161**.

The session manager **161** sends reference information to the controller object **200** indicating the session ID, party ID, and secret ID. The session manager **161** also sends a Join Stream message to the controller object **200**. In response, the controller object **200** generates and transmits reference information to the session manager **161** with the terminal ID, the party ID, and the VPI/VCI. The session manager **161** sends a Confirm message to the controller object **200** and the controller object **200** sends a confirm indication to the port object **201**. In response to the confirm indication, the port object **201** sends "open voice channel (A, VPI/VCI)" to the telephony card. At this point, the session manager **161** has the information to set-up the connection. Subsequently, the session is in progress and the telephone call can proceed.

The session ends when a termination message is received by the controller object **200** from the session manager **161**. The controller object **200** indicates the termination status to the port object **201** which sends "close voice channel (A, VPI/VCI)" to the telephony card **150**. The telephony card **150** ceases to interwork channel A with the VPI/VCI.

It should be appreciated that various combinations of call origination and termination can occur in the context of the invention. For example the phone **151** can originate a call or receive a call. Likewise, the phone **151** can terminate a call or the called party can terminate a call. It should also be appreciated that the port object **202** and the event object **204** operate in a similar fashion to the port object **201** and the event object **203** respectively. Using these objects, the provider agent can handle multiple sessions at the same time. A provider agent can have numerous such objects, but only two groups are shown for purposes of clarity.

Race conditions exist when improper events occur given the current state of the port objects **151–152**. This typically occurs when calls are incoming and outgoing at the same moment. One example is where an invite message is received by the controller object **200**, and the controller object **200** determines that the status of channel A is idle, but in reality, the port object **201** is already in the dial tone state due to an off-hook event. The port object **201** will receive an invite indication from the controller object **200** when it expects to receive digit indications from the event object **203**. In this case, the port object **201** must instruct the controller object **200** to reply busy or reject, and to set channel A status to busy.

In another example, the controller object **200** may receive an invite message from the session manger **161**, but before the phone **151** rings, the phone **151** goes off-hook. The port object **201** will receive an invite indication from the controller object **200** and an off-hook event from the telephony card **150**. In this case, the port object **201** instructs the telephony card **150** to open the voice channel and VPI/VCI for the incoming call as if the phone was answered for that call.

The Residential Hub—FIG. **7**

FIG. **7** depicts an example of the residential hub **721** in some embodiments of the invention, but variations in the residential hub **721** are contemplated by the invention. Conventional requirements for the residential hub **721** can be found in Telecommunications Industry Association (TIA) document SP-3771. The telephones **701** and **702** are connected to the residential hub **721** by connections **711** and **712** respectively. The residential hub **721** is connected to the DSL mux **722** by connection **713**. The DSL mux **722** is connected to the ATM switch **723** by connection **730**.

The telephones **701** and **702** are conventional communications devices that use the analog telephony format. The connections **711** and **712** are any medium operational to carry analog telephony signals, and the connections **71** land **712** are typically twisted pairs of copper wires. The connection **713** is also capable of carrying signals using the ATM/DSL format. The ATM/DSL format is a DSL signal that transports ATM cells as the high-bandwidth data.

The residential hub **721** is located at a residence. A residence is a conventional dwelling where people reside, such as a house, duplex, apartment, or condominium. The residential hub **721** provides an analog telephony interface to the telephones **701** and **702**. The residential hub **721** provides an ATM/DSL interface to the DSL mux **722**. The residential hub **721** executes provider agent software that directs system operation.

The DSL mux **722** is a device that interworks the ATM/ADSL format with an ATM/broadband format. The ATM/broadband format is a broadband signal that transports ATM cells. Synchronous Optical Network (SONET) is a popular broadband format, and the ATM/SONET format is well known. Preferably, the DSL mux **722** includes redundant OC-3 network interfaces and handles up to 255 residences on the access side. The DSL mux **722** should be able to differentiate data from voice. In some embodiments, the DSL mux **722** could be adapted to provide Switched Virtual Circuits (SVCs) to the ATM switches **723**. The DSL mux **722** could be adapted from the DSL product provided by Westell.

The ATM switch **723** is able to establish SVCs and Permanent Virtual Circuits (PVCs). The ATM switch **723** is conventional such as the Vector switch supplied by Nortel. The connection **730** carries the ATM/broadband format. In some embodiments the connection **730** carries the ATM/SONET format. For example, the connection **730**; could be comprised at least in part of a Broadband Metropolitan Area Network (BMAN) that uses a 4-fiber, bi-directional, line switched, self-healing, OC-3 SONET ring.

There are various ATM connectivity options between the ATM switch **723** and the residential hub **721**. ATM connections could be provisioned as PVCs from the residential hub **721** directly to the ATM switch **723**. PVCs tend to waste bandwidth in the SONET rings comprising the connection **730**. ATM connections could be provisioned from the residential hub **721** to the DSL mux **722**, and the DSL mux **722** and the ATM switch **723** could establish SVCs to communicate. The entire connection between the residential hub **721** could be established with SVCs as needed. Combinations of PVCs and SVCs could also be used. For example, low bandwidth control channels could be provisioned directly from the residential hub **721** to the ATM switch **723**, but higher bandwidth user channels could be established on an SVC basis.

The residential hub **721** includes an ATM/DSL interface **761**, an ATM backplane **762**, a telephony card **763**, and other cards **764**. The telephones **701** and **702** are connected to the telephony card **763** by connections **711** and **712**. The ATM/DSL interface **761** is connected to the DSL mux **722** by connection **713**. An uninterruptable power supply (UPS) may be included if desired in order to provide power during an outage to the residence.

The ATM/DSL interface **761** provides smoothing and shaping for the ATM signals. The ADSL/ATM interface **761** converts control and communications ATM cells into the ATM/DSL format for transport to the DSL mux **722**. The ATM/DSL interface **761** also receives control and communications ATM cells from the DSL mux **722** and provides these to the appropriate components of residential hub **721** using the ATM backplane **762**. The ATM backplane **762** allows for ATM communications within the residential hub **721**.

The telephony card **763** supports analog telephony communications with the telephones **701** and **702**. The telephony card **763** is controlled by a provider agent that is resident in the residential hub **721**. The telephony card **763** provides power and dial tone to the telephones. The telephony card **763** detects on-hook, off-hook, and DTMF tones. The telephony card **763** provides ringback and busy tones to the telephones **701** and **702**. The telephony card **763** interworks analog telephony signals with ATM signals. In some embodiments, the telephony card **763** provides echo cancellation or other digital signal processing functions. The telephony card **763** could be adapted from the telephony card product supplied by Innomedia Logic of Quebec, Canada.

The other cards **764** represent a number of different cards that can be plugged into the residential hub. Empty slots for additional cards are also shown on the ATM backplane. Some examples of other cards **764** include a Java card, ATM card, MPEG card, utility card, or LAN card. The cards provide communications services to the end users as discussed below.

The Java card includes a processor and memory and is operational to receive Java applets from the service node. Java applets can support a wide variety of tasks. In particular, Java applets can be used to provide the intelligence to support class 5 features, such as call waiting and call forwarding. The Java card also exerts control over the cards and DSL/ATM interface **761**. This could include ATM virtual connection assignments for communications to the mux or a service node. The Java card may also communicate with the service node to request numerous other communications services. The ATM card provides an ATM interface to devices within the residence. If the ATM card exchanges ATM signaling with resident devices over VPI=0 and VPI=5, then the ATM card may use virtual path associated signaling to exchange control information with the service node. The MPEG card provides an MPEG interface to devices within the residence. MPEG is a video formatting standard. Typically, the MPEG card will receive MPEG formatted video in ATM cells through the ATM/DSL interface **761** and provide video signals to devices in the residence. The utility card is coupled to utility metering devices in the home. The utility card is programmed to collect the metering information and forward it to the utility companies through ATM/DSL interface **761**. The LAN card supports a LAN that is internal to the residence. For, example, the LAN card could support ethernet connections to multiple computers. The computers could access the Internet through the LAN card and ATM/DSL interface **761**.

The invention is not restricted to basic telephone service. A subscription/configuration service could also be deployed. The provider agent would analyze the called number to determine if telephone service or the subscription/configuration service is requested. The provider agent would then direct the telephony card to couple the call to the requested service. Other services could be implemented in a similar fashion.

Those skilled in the art can appreciate variations of the above-described embodiments that fall within the scope of the invention. As a result, the invention is not limited to the specific embodiments discussed above, but only by the following claims and their equivalents.

What is claimed is:

1. A method of operating a communication system having a session manager and network elements to provide telephony service to a user having a communication hub and an analog telephone wherein the communication hub is configured to interwork between the analog telephone and a digital communication link, the method comprising:

- transferring a software agent to the communication hub wherein the software agent is operational when executed by the communication hub to manage off-hook detection, dial-tone generation, called number digit collection, and ring-back generation for the analog telephone to establish a telephone call, and to exchange control messages with the session manager to establish the telephone call;
- in the session manager, exchanging the control messages with the software agent in the communication hub, and in response, controlling the network elements to establish the telephone call; and
- in the network elements, providing a digital communication service for the telephone call over the digital communication link in response to the session manager control.

2. The method of claim **1** wherein transferring the software agent to the communication hub comprises downloading the software agent from a server over the Internet.

3. The method of claim **1** wherein providing the digital communication service over the digital communication link comprises providing Asynchronous Transfer Mode service.

4. The method of claim **1** wherein providing the digital communication service over the digital communication link comprises providing Digital Subscriber Line service.

5. The method of claim **1** wherein providing the digital communication service over the digital communication link comprises providing Internet Protocol service.

6. The method of claim **1** wherein providing the digital communication service over the digital communication link comprises providing Synchronous Optical Network service.

7. The method of claim **1** wherein the software agent is configured to manage call waiting.

8. The method of claim **1** wherein the software agent is configured to manage voice mail.

9. The method of claim **1** wherein the software agent is configured to manage call blocking.

10. The method of claim **1** wherein the software agent is configured to manage call routing to the analog telephone.

11. The method of claim **1** wherein the software agent is configured to exchange control messages with an application programming interface for a telephony card in the communication hub.

12. The method of claim **11** wherein the control messages comprise start ring, stop ring, start tone, stop tone, open voice channel, and close voice channel.

13. A communication system to provide telephony service to a user having a communication hub and an analog telephone wherein the communication hub is configured to interwork between the analog telephone and a digital communication link, the communication system comprising:

- a server configured to transfer a software agent to the communication hub wherein the software agent is operational when executed by the communication hub to manage off-hook detection, dial-tone generation, called number digit collection, and ring-back generation for the analog telephone to establish a telephone call, and to exchange control messages to establish the telephone call;
- a session manager configured to exchange the control messages with the software agent in the communication hub, and in response, to control the communication system to establish the telephone call; and
- network elements configured to provide a digital communication service for the telephone call over the digital communication link in response to the session manager control.

14. The communication system of claim **13** wherein the server is configured to download the software agent to the communication hub over the Internet.

15. The communication system of claim **13** wherein the network elements are configured to provide Asynchronous Transfer Mode service over the digital communication link.

16. The communication system of claim **13** wherein the network elements are configured to provide Digital Subscriber Line service over the digital communication link.

17. The communication system of claim **13** wherein the network elements are configured to provide Internet Protocol service over the digital communication link.

18. The communication system of claim **13** wherein the network elements are configured to provide Synchronous Optical Network service over the digital communication link.

19. The communication system of claim **13** wherein the software agent is configured to manage call waiting.

20. The communication system of claim **13** wherein the software agent is configured to manage voice mail.

21. The communication system of claim **13** wherein the software agent is configured to manage call blocking.

22. The communication system of claim **13** wherein the software agent is configured to manage call routing to the analog telephone.

23. The communication system of claim **13** wherein the software agent is configured to exchange control messages with an application programming interface for a telephony card in the communication hub.

24. The communication system of claim **23** wherein the control messages comprise start ring, stop ring, start tone, stop tone, open voice channel, and close voice channel.

* * * * *

EXHIBIT E

US008121028B1

(12) **United States Patent**
Schlesener et al.

(10) **Patent No.: US 8,121,028 B1**
(45) **Date of Patent: Feb. 21, 2012**

(54) **QUALITY OF SERVICE PROVISIONING FOR PACKET SERVICE SESSIONS IN COMMUNICATION NETWORKS**

(75) Inventors: **Matthew C. Schlesener**, Olathe, KS (US); **Pallavur Sankaranaraynan**, Overland Park, KS (US); **Brian D. Mauer**, Shawnee, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 989 days.

(21) Appl. No.: **11/324,671**

(22) Filed: **Jan. 3, 2006**

(51) **Int. Cl.**
H04L 12/28 (2006.01)

(52) **U.S. Cl.** **370/230**

(58) **Field of Classification Search** 370/234, 370/254, 392, 465; 709/238, 245, 223, 227, 709/228; 713/182; 725/109, 111
See application file for complete search history.

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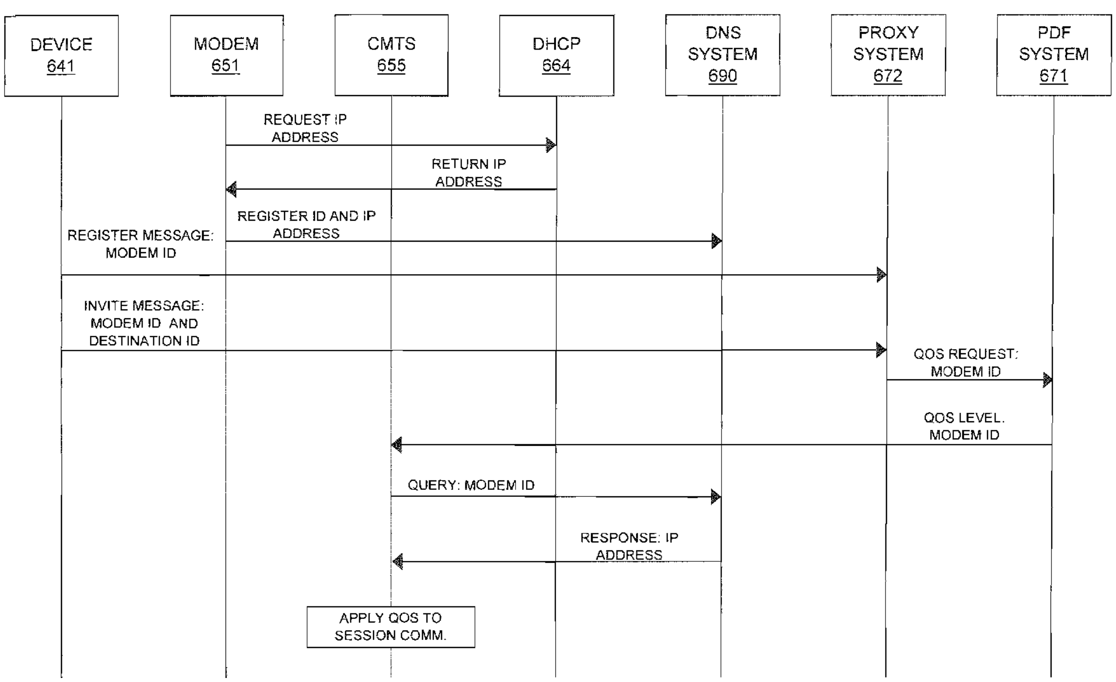
Primary Examiner — Chi Pham
Assistant Examiner — Mohammad Adhami

(57) **ABSTRACT**

A communication system comprises an end system coupled to an access system and configured to transmit an invite message for a session wherein the invite message indicates a destination and an alias for the end system, a proxy system configured to receive the invite message and transfer a quality request wherein the policy request indicates the alias, a policy system configured to receive the quality request, determine a quality level for the session and transmit a quality message to the access system indicating the alias and the quality level, and the access system configured to receive the quality message, transmit a query to a database system indicating the alias, receive a network address for the end system in response to the query, identify traffic for the session using the network address, and apply the quality level to the traffic.

4 Claims, 8 Drawing Sheets



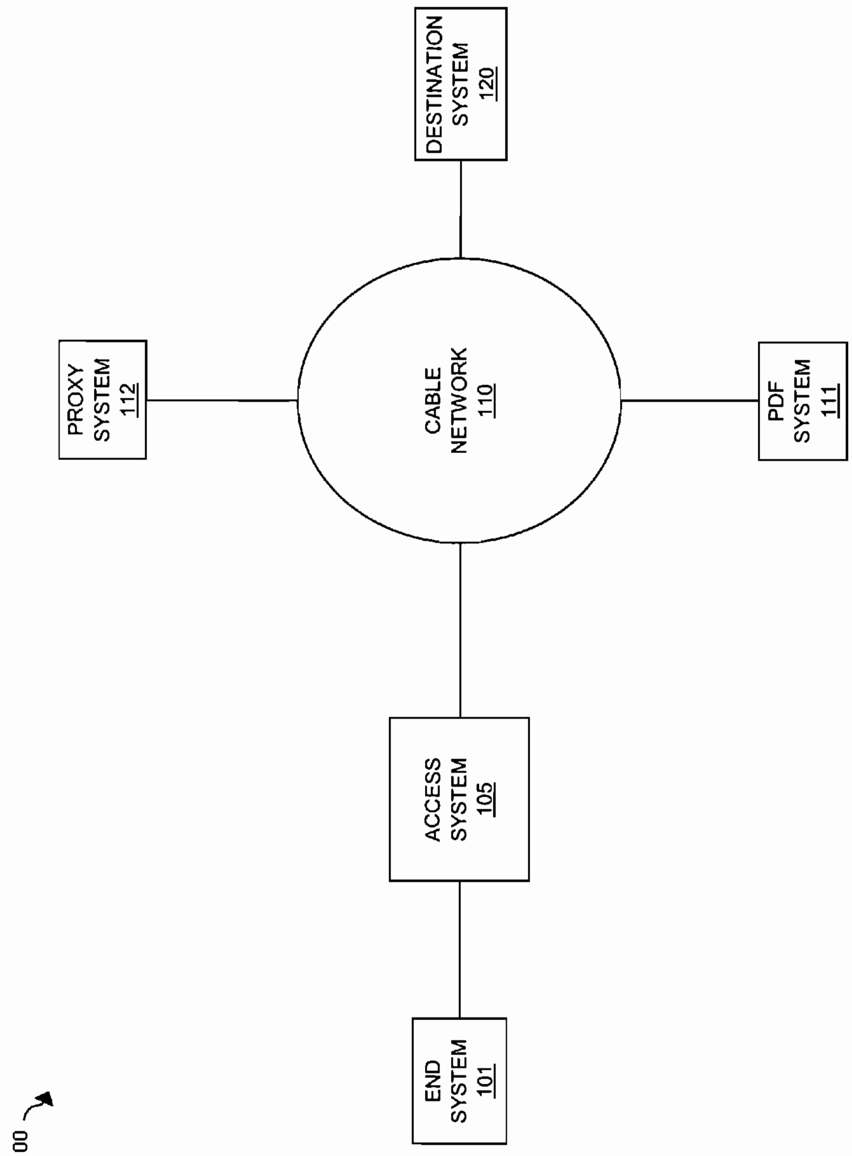


FIG. 1 (PRIOR ART)

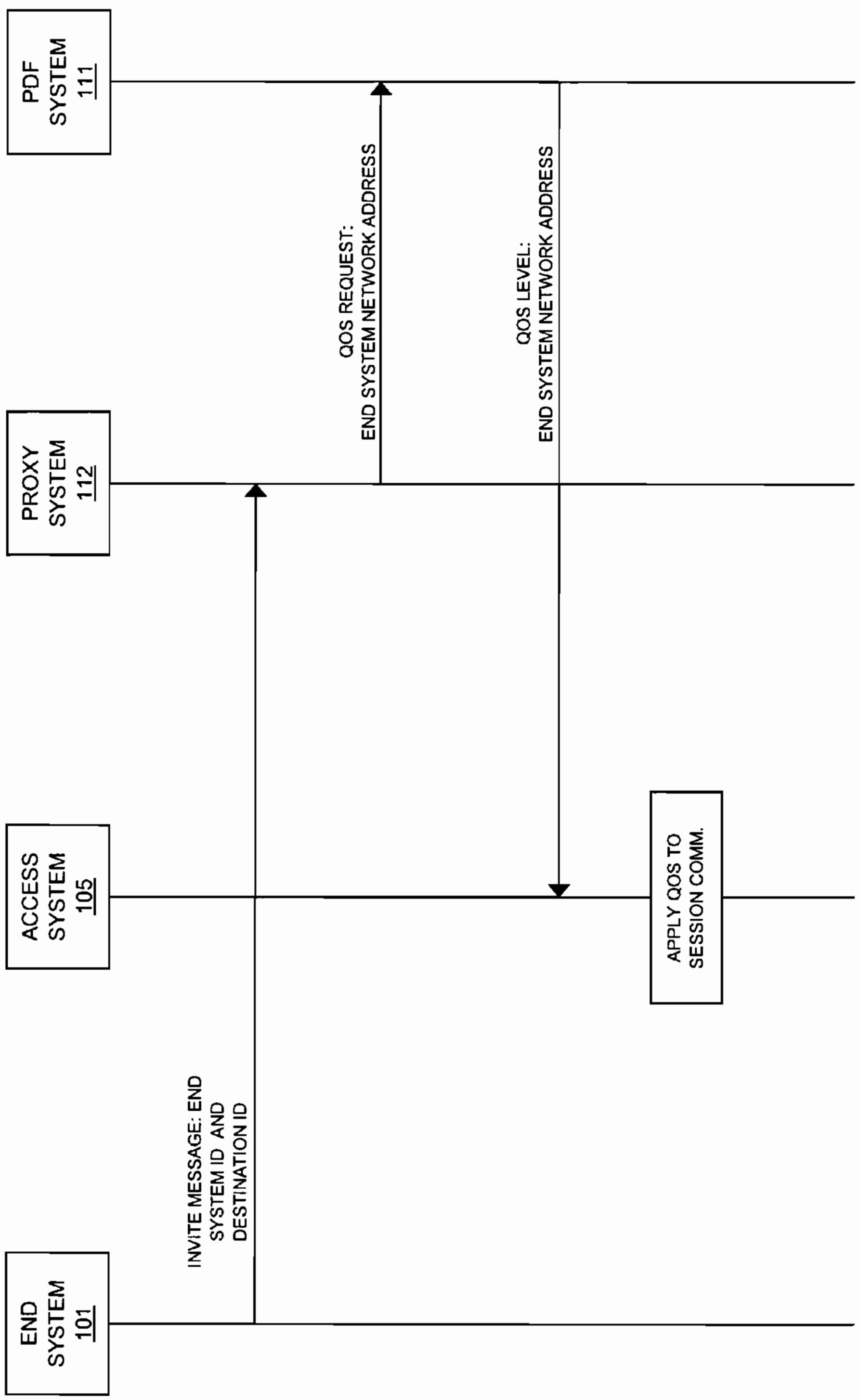
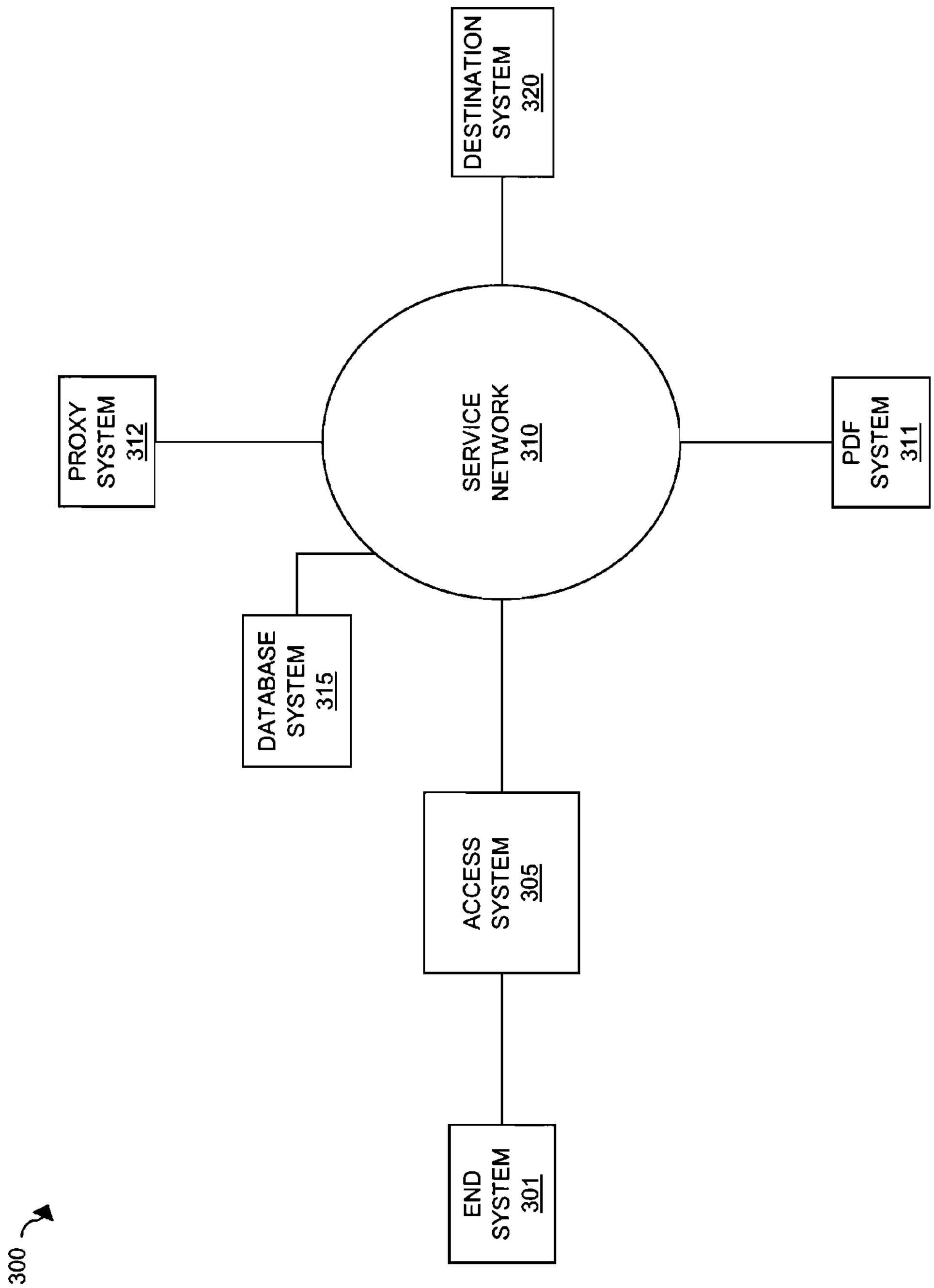


FIG. 2 (PRIOR ART)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PROXY SYSTEM 312
SERVICE NETWORK 310
PDF SYSTEM 311
DATABASE SYSTEM 315
ACCESS SYSTEM 305
END SYSTEM 301
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FIG. 3

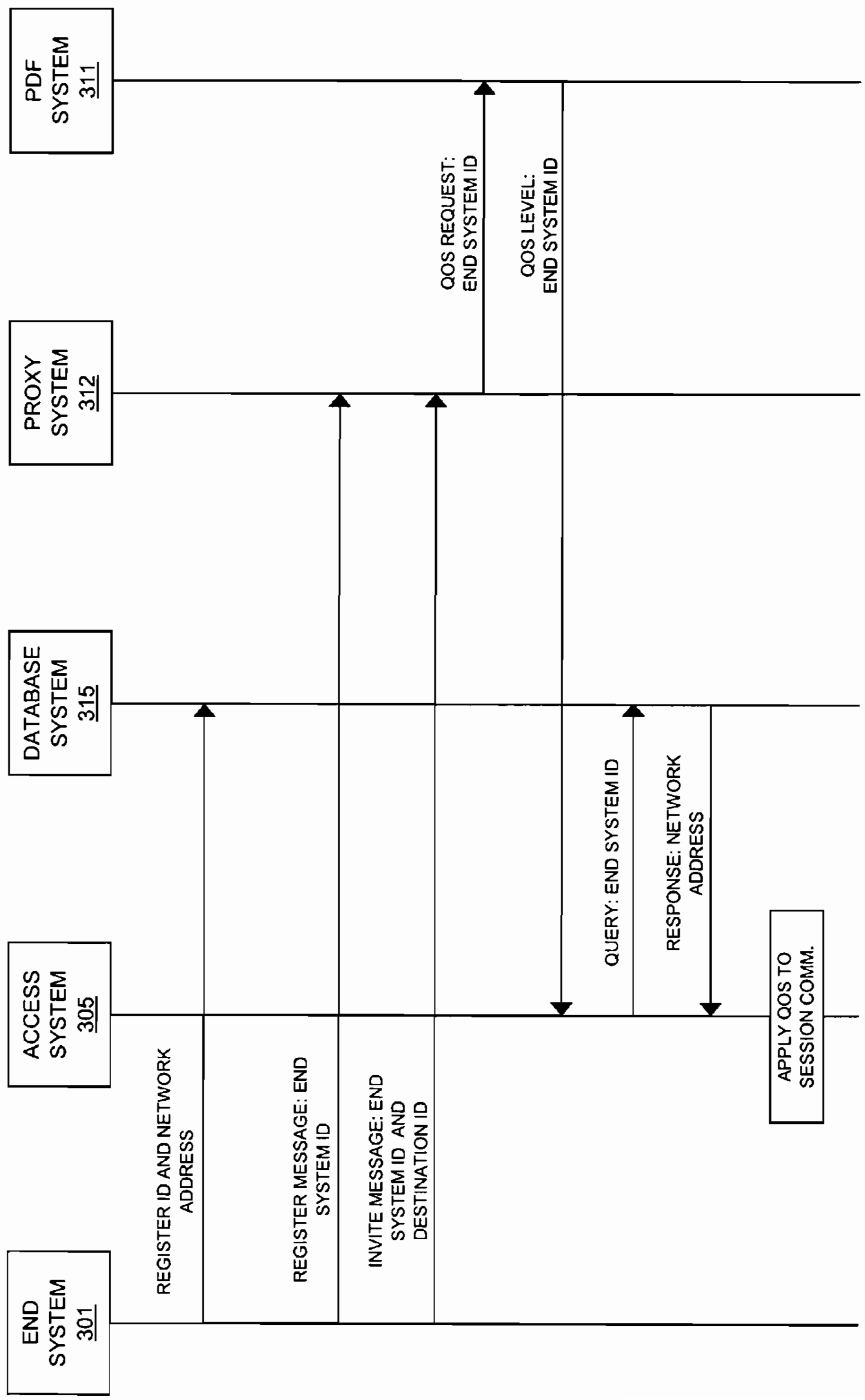
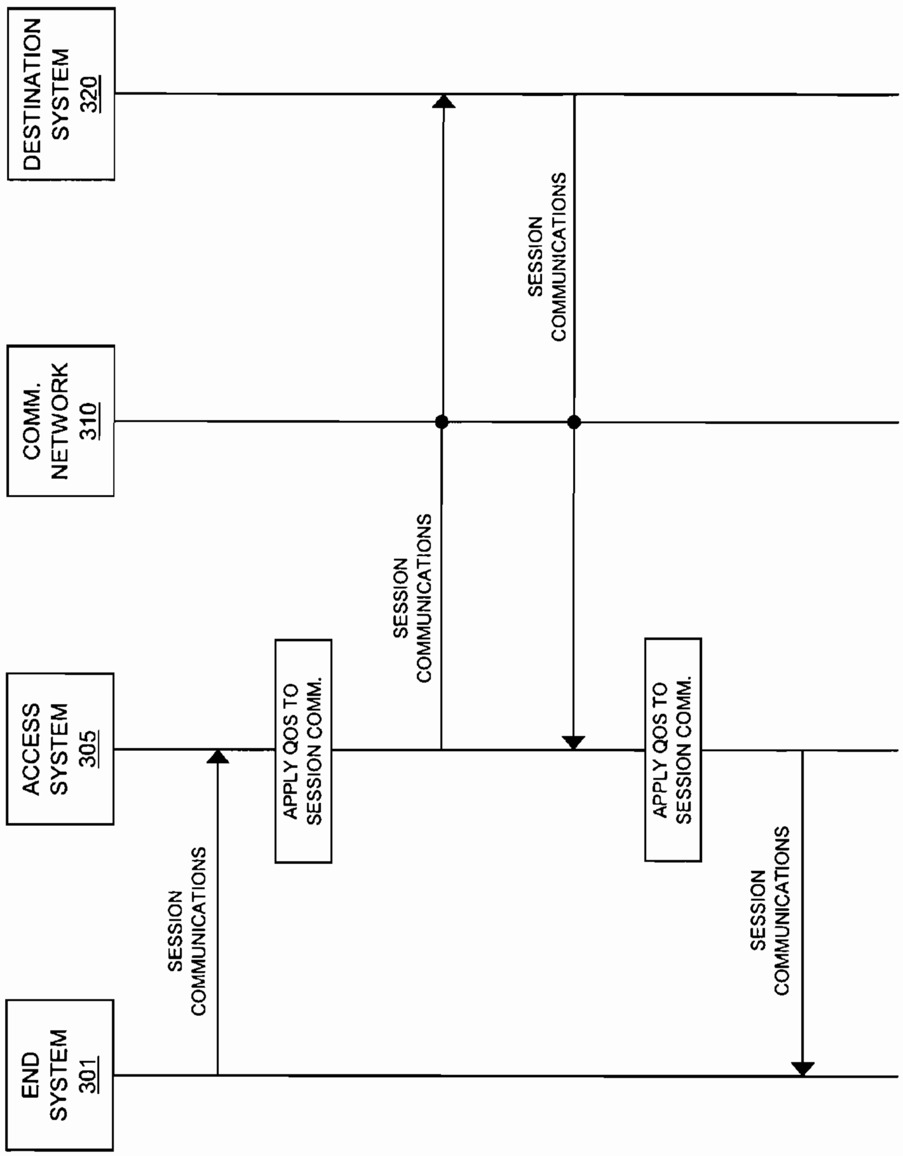

PDF SYSTEM 311
PROXY SYSTEM 312
DATABASE SYSTEM 315
ACCESS SYSTEM 305
END SYSTEM 301
REGISTER ID AND NETWORK ADDRESS
REGISTER MESSAGE: END SYSTEM ID
INVITE MESSAGE: END SYSTEM ID AND DESTINATION ID
QOS REQUEST: END SYSTEM ID
QOS LEVEL: END SYSTEM ID
QUERY: END SYSTEM ID
RESPONSE: NETWORK ADDRESS
APPLY QOS TO SESSION COMM.

FIG. 4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COMM. NETWORK 310
ACCESS SYSTEM 305
END SYSTEM 301
SESSION COMMUNICATIONS
APPLY QOS TO SESSION COMM.
SESSION COMMUNICATIONS
SESSION COMMUNICATIONS
APPLY QOS TO SESSION COMM.
SESSION COMMUNICATIONS

FIG. 5

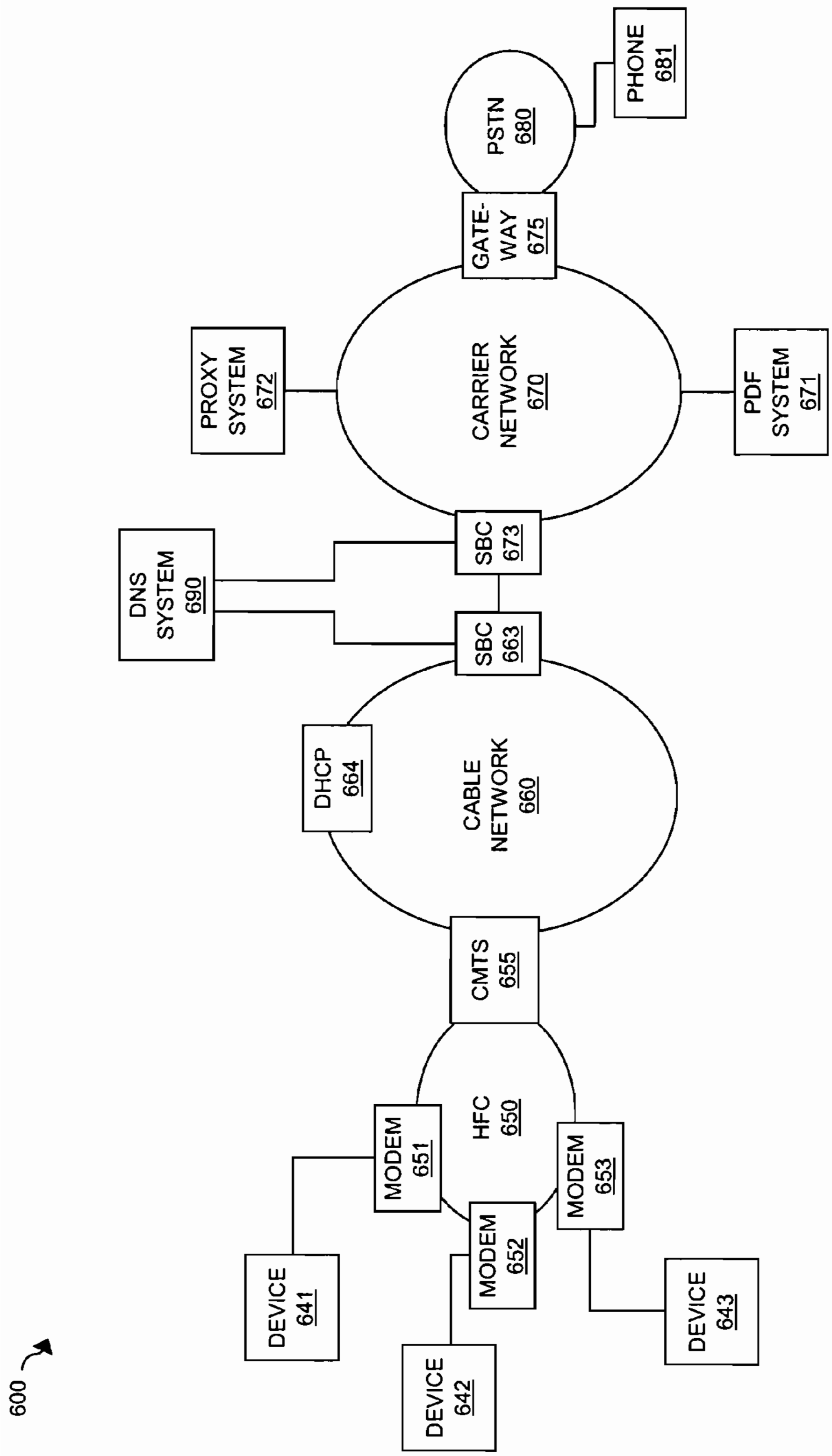
600
PHONE 681
PSTN 680
GATE-WAY 675
PROXY SYSTEM 672
CARRIER NETWORK 670
PDF SYSTEM 671
DNS SYSTEM 690
SBC 673
SBC 663
DHCP 664
CABLE NETWORK 660
CMTS 655
HFC 650
MODEM 651
MODEM 652
MODEM 653
DEVICE 641
DEVICE 642
DEVICE 643

FIG. 6

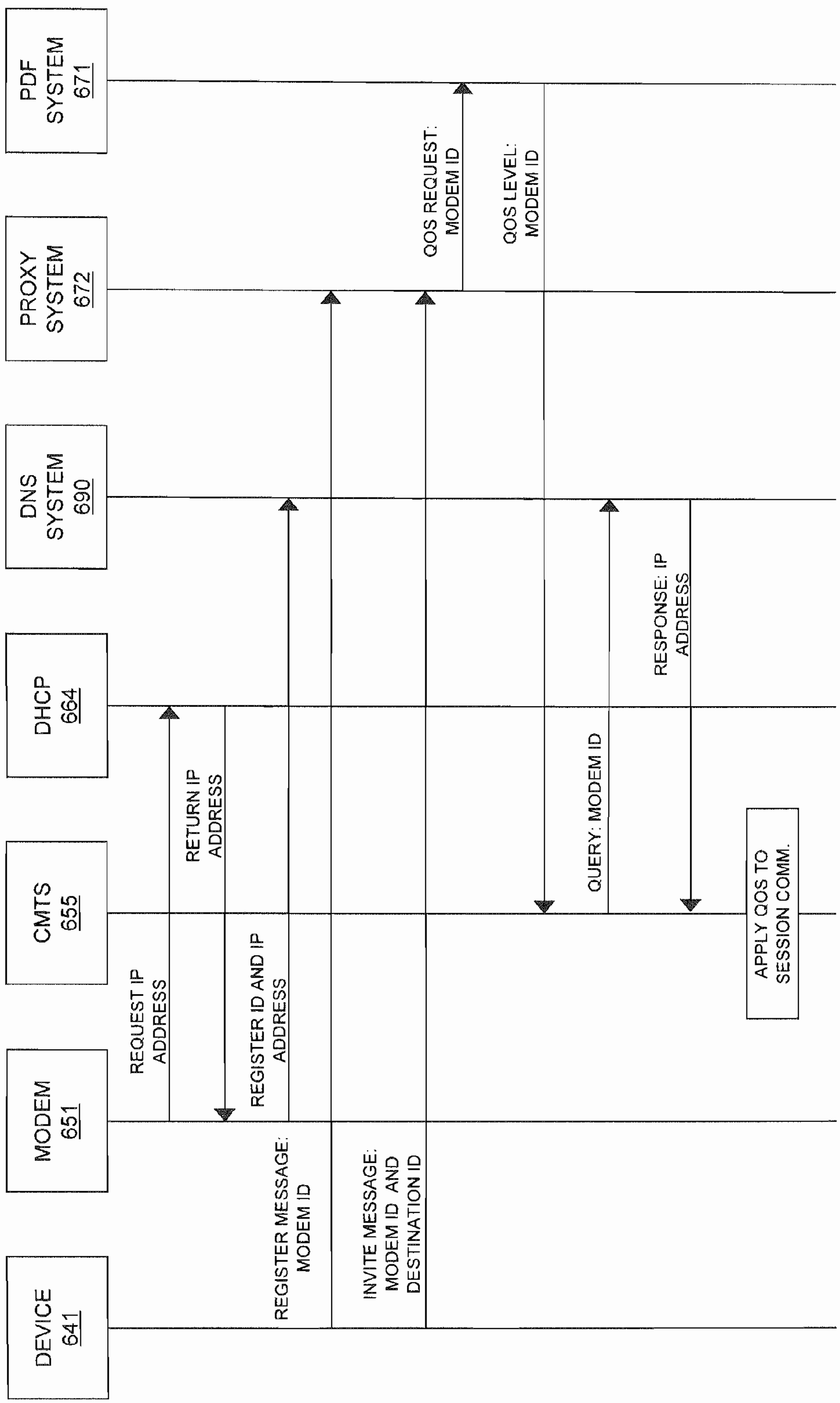
DEVICE 641
MODEM 651
CMTS 655
DHCP 664
DNS SYSTEM 690
PROXY SYSTEM 672
PDF SYSTEM 671
REQUEST IP ADDRESS
RETURN IP ADDRESS
REGISTER ID AND IP ADDRESS
REGISTER MESSAGE: MODEM ID
INVITE MESSAGE: MODEM ID AND DESTINATION ID
QOS REQUEST: MODEM ID
QOS LEVEL: MODEM ID
QUERY: MODEM ID
RESPONSE: IP ADDRESS
APPLY QOS TO SESSION COMM.

FIG. 7

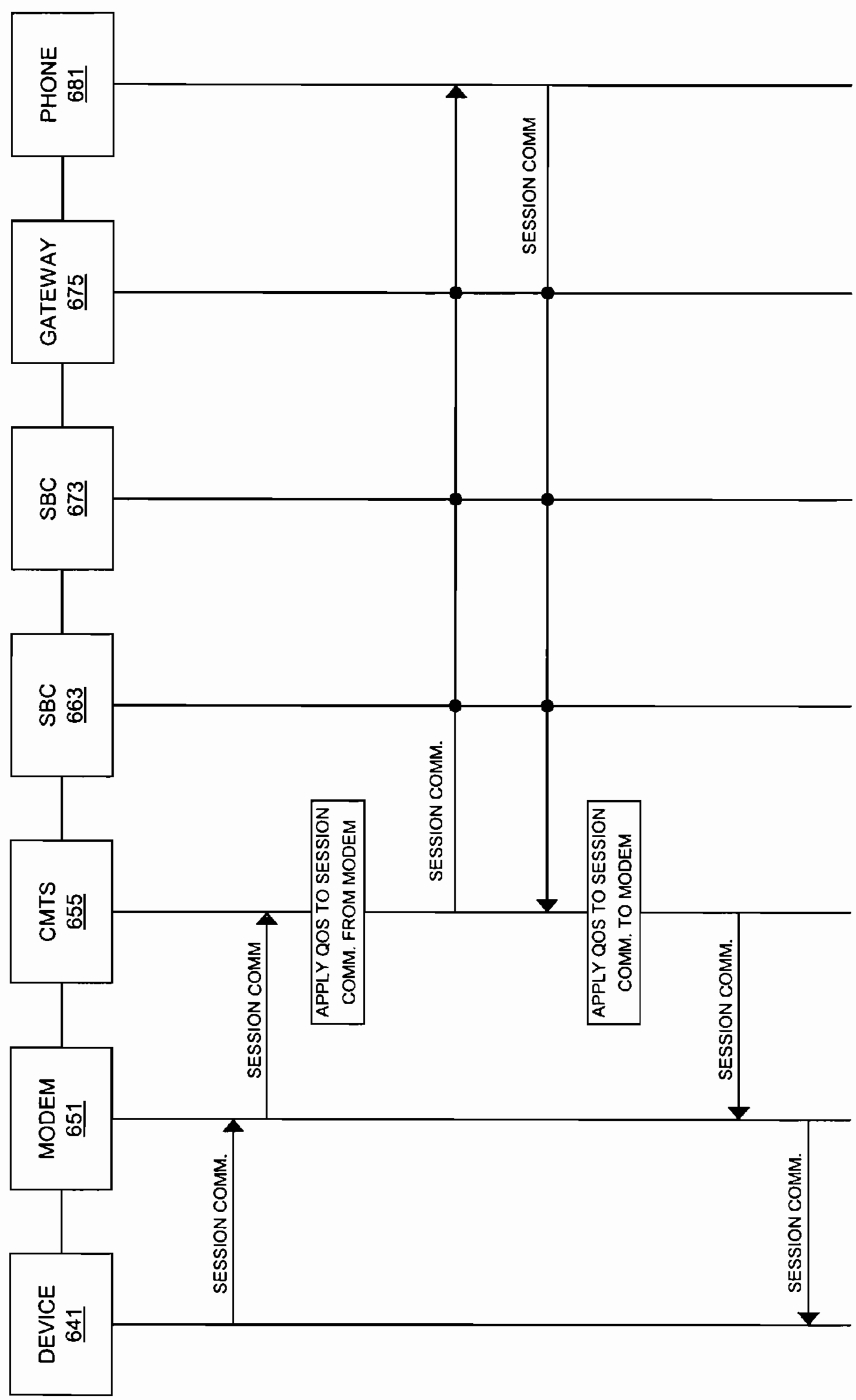
PHONE 681
GATEWAY 675
SBC 673
SBC 663
CMTS 655
MODEM 651
DEVICE 641
SESSION COMM.
SESSION COMM
APPLY QOS TO SESSION COMM. FROM MODEM
SESSION COMM.
SESSION COMM
APPLY QOS TO SESSION COMM. TO MODEM
SESSION COMM.
SESSION COMM.

FIG. 8

QUALITY OF SERVICE PROVISIONING FOR PACKET SERVICE SESSIONS IN COMMUNICATION NETWORKS

RELATED APPLICATIONS

Not applicable

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to packet services in communication networks, and in particular, to the provisioning of quality of service levels for service sessions.

2. Description of the Prior Art

Recently, cable companies have begun to offer voice services in addition to the standard data and entertainment services of the past. The most common voice service offered is voice over packet (VoP), of which Voice over Internet Protocol (VoIP) is a well known example. Cable companies that offer multiple types of services are often times referred to as multi-system operators, or MSOs.

End users, such as residential and business customers, are accustomed to high levels of quality of service (QoS) from circuit switched voice providers, such as the local exchange carriers (LECs) that form portions of the public switched telephone network (PSTN). In order to compete with circuit switched voice providers, MSOs must be able to provide QoS at comparable levels.

FIG. **1** illustrates a communication network **100** in the prior art for providing QoS in a cable MSO network. Communication network **100** includes cable network **110**, access system **105**, destination system **120**, end system **101**, proxy system **112**, and policy decision function (PDF) system **111**. In communication network **110**, cable network **110** provide transport for communications between access system **105** and destination system **120**. Access system **105** provides end system **101** with access to cable network **110**. End system **101** is typically connected to access system **105** by a hybrid fiber/coaxial connection (HFC). Cable network **110** is often times a high-speed Ethernet network, such as Gig-Ethernet. Proxy system **112** is typically a session initiation protocol (SIP) proxy system. Likewise, end system **101** could include a SIP end device. Proxy system **112** operates in accordance with well known protocols, such as SIP).

In operation, end system **101** registers with proxy system **112**, including transmitting the network address of end system **101**, such as its IP address, to proxy system **112**. Proxy system **112** stores the current network address of end system **101** for later call processing.

FIG. **2** illustrates the operation of communication network **100** for provisioning QoS for a VoP session between end system **101** and destination system **120** in an example of the prior art. To begin, end system **101** transmits a SIP invite message to proxy system **112**. The invite message indicates an identifier for end system **101** and a destination identifier for destination system **120**. Proxy system **112** typically processes the invite message to perform call setup processes to setup a VoP call between end system **101** and destination system **120**. As part of the call setup process, proxy system **112** transmits a QoS request to PDF system **111**. The request indicates the network address for end system **101**. In response, PDF system **111** looks up the requested QoS information and transmits the resulting QoS information to access system **105**. Access system **105** configures the links between end system **101** and access system **105** in accordance with the QoS information. The appropriate QoS level is then applied to the VoP session between end system **101** and destination system **120**.

One prior problem illustrated by FIG. **2** is that the current network address of end system **101** is required by PDF system **111** and access system **105** in the QoS provisioning process. In many cases, MSOs partner with third-party carriers to provide VoP services to the MSO customers. However, common boundary devices, such as session border controllers, block actual network addresses from passing across peered network borders. As a result, MSOs face increasing challenges in their attempts to provide high levels of QoS to customers who have become accustomed to the high QoS of the PSTN. In addition, carriers face increased challenges to their ability to provide QoS control over sessions originating from or terminating to a peered MSO network due to the presence of session border controllers.

SUMMARY OF THE INVENTION

An embodiment of the invention helps solve the above problems and other problems by providing systems and methods that allow a carrier network to retain call control over sessions originating from or terminating to a peered MSO network, even though visibility across the networks is reduced due to the presence of session border controllers.

In an embodiment of the invention, a communication system comprises an end system coupled to an access system and configured to transmit an invite message for a session wherein the invite message indicates a destination and an alias for the end system, a proxy system configured to receive the invite message and transfer a quality request wherein the policy request indicates the alias, a policy system configured to receive the quality request, determine a quality level for the session and transmit a quality message to the access system indicating the alias and the quality level, and the access system configured to receive the quality message, transmit a query to a database system indicating the alias, receive a network address for the end system in response to the query, identify traffic for the session using the network address, and apply the quality level to the traffic.

In an embodiment of the invention, the access system comprises a cable modem termination system (CMTS).

In an embodiment of the invention, the end system comprises a device coupled to a modem.

In an embodiment of the invention, the network address is a dynamic Internet Protocol (IP) address for the modem.

In an embodiment of the invention, the alias comprises a hard coded domain name service (DNS) name for the modem.

In an embodiment of the invention, the database system comprises a domain name service (DNS) server.

In an embodiment of the invention, the session comprises a voice over Internet Protocol (VoIP) session.

BRIEF DESCRIPTION OF THE DRAWINGS

The same reference number represents the same element on all drawings.

FIG. **1** illustrates a communication network in an example of the prior art.

FIG. **2** illustrates a flow diagram in an example of the prior art.

FIG. **3** illustrates a communication network in an embodiment of the invention.

FIG. **4** illustrates a flow diagram in an embodiment of the invention.

FIG. **5** illustrates a flow diagram in an embodiment of the invention.

FIG. **6** illustrates a communication network in an embodiment of the invention.

FIG. **7** illustrates a flow diagram in an embodiment of the invention.

FIG. **8** illustrates a flow diagram in an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. **3**-**8** and the following description depict specific embodiments of the invention to teach those skilled in the art how to make and use the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these embodiments that fall within the scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple embodiments of the invention. As a result, the invention is not limited to the specific embodiments described below, but only by the claims and their equivalents.

First Embodiment Configuration and Operation—FIGS. 3-5

FIG. **3** illustrates communication network **300** in an embodiment of the invention. In this embodiment, the actual network address of an end system may be used by certain network elements, such as an access system, for configuring a session for QoS. Further in this embodiment, an alias identifier may be used by other network elements, such as a proxy system or a PDF system, for determining and informing the access system of the appropriate QoS. A database system is provided for correlating the network address of an end system with the alias identifier for the end system.

In particular, communication network **300** includes service network **310**, access system **305**, destination system **320**, end system **301**, proxy system **312**, PDF system **311**, and database system **315**. End system **301** is operatively coupled to access system **305**. Access system **305** is operatively coupled to service network **310**. Database system **315**, proxy system **312**, PDF system **311**, and destination system **320** are also operatively coupled to service network **310**. Service network **310** could be any network or collection of networks configured to provide transport and control for the exchange of communications, such as session bearer and control traffic, as well as other types of communications.

Access system **305** is any system capable of providing service access for end system **301** to service network **310**. Access system **305** is also any system capable of providing QoS treatment to service sessions between end system **301** and destination system **320**. Examples of service sessions include VoP sessions, video sessions, and gaming sessions, as well as other types of sessions. In one example, access system **305** could be a cable modem termination system (CMTS), as well as other types of access systems.

End system **301** is any system capable of participating as an end system on a session with destination system **320**. End system **301** could be a system of collection of systems, such as a wireless or wireline phone, personal digital assistant, multi-media devices, pager, or modem, as well as other types of systems. Destination system **320** could be any system or collection of systems capable of participating with end system **301** on a session.

Proxy system **312** could be any system capable of providing session control for sessions between end system **301** and destination system **320**. For instance, proxy system **312** could be capable of communicating with PDF system **311** to determine QoS levels for sessions between end system **301** and destination system **320**. Proxy system **312** could be a system or collection of systems. For example, proxy system **312** could be a sub system in a soft-switch. Proxy system **312** could be a stand-alone system separate from a soft-switch. Proxy system **312** could also be considered a soft-switch itself. Other variations are possible. In one example, proxy system **312** could be a SIP proxy server, as well as other types of proxy systems.

PDF system **311** could be any system capable of communicating with proxy system **312** and access system **305** to coordinate and provision QoS for sessions between end system **301** and destination system **320**. PDF system **311** could be an individual system or collection of systems.

Database system **315** could be any system capable of storing network addresses in association with alias identifiers. In addition, database system **315** could be any system capable of receiving registration messages indicating network addresses and their associated alias identifiers. Furthermore, database system **315** could be any system capable of receiving and processing queries from access system **305** and transmitting responses back to access system **305**.

FIG. **4** is a flow diagram illustrating the operation of communication network **300** in an embodiment of the invention. In this embodiment, QoS is provisioned for a session between end system **301** and destination system **320**. To begin, end system **301** registers its alias identifier (ID) and actual network address with database system **315**. Next, end system **301** transmits a registration message to proxy system **312** notifying proxy system **312** of the presence of end system **301** and the alias ID of end system **301**. Proxy system **312** can then use the information for well known call processing. At this stage, database system **315** holds the current network address for end system **301** and the alias ID for end system **301**. The alias ID does not identify the current network address.

After completing the registration process, a user desires to place a VoP call to destination system **320**. In response to a user input, such as dialing a phone number, end system **301** transmits an invite message to proxy system **312**. The invite message identifies destination system **320**, such as by the phone number, as the alias ID of end system **301**. Proxy system **312** processes the invited in accordance with well known call processing, including transmitting a QoS request to PDF system **311**. However, in a departure from the prior art, the QoS request indicates the alias ID for end system **301**, rather than the actual network address.

Upon receiving the QoS request from proxy system **312**, PDF system **311** processes the request to determine the appropriate QoS for the requested session between end system **301** and destination system **320**. PDF system **311** determines the QoS in accordance with well known principles, such as by performing a table lookup. The lookup could be performed based on a user ID associated with the user using end system **301**, the alias ID of end system **301**, or the ID of access system **305**. Other well known ways of determining the QoS are possible.

After determining the QoS, PDF system **311** transmits a message to access system **305** indicating the QoS and the alias ID for end system **301**. Access system **305** receives the message and transmits a query to database system **315** indicating the alias ID. Database system **315** processes the query to determine the network address associated with the alias ID. Upon determining the network address, database system **315** transmits a response to access system **305** indicating the network address associated with the alias ID. Access system **305** is advantageously able to identify session traffic associated with the network address and apply the correct QoS treatment to the session traffic.

FIG. **5** is a flow diagram further illustrating the operation of communication network **300** in an embodiment of the invention. In FIG. **5**, a two-way session flow is illustrated, although a session could be one-way. In this embodiment, end system **301** transmits session communications to access system **305**. Access system **305**, knowing the network address of end system **301**, applies the appropriate QoS to the session communications. For instance, access system **305** could provide priority to the session communications in preference over other types of communications, such as non-voice communications. Other types of prioritization are possible. Access system **305** forwards the session communications to communication network **310**. Communication network **310** in turn transports the communications to destination system **320**.

In the opposite direction, destination system **320** transmits session communications to communication network **310**. Communication network **310** transports the communications to access system **305**. Access system **305** applies the appropriate QoS to the session communications, and forwards the communications to end system **301**. End system **301** provides the communications in a usable form, such as an audio or video output, to a user.

Although not pictured, the following describes the session termination process with respect to FIGS. **3-5**. Once the session is concluded, end system **301** transmits a termination message to proxy system **312**. Proxy system **312** passes a control message to PDF system **311** indicating the alias ID for end system **301** and instructing PDF system **311** to release access system **305** from the QoS requirements for the session. PDF system **311** responsively transmits a release message to access system **305** to release the session QoS parameters. The release message identifies end system **301** by the alias ID. Access system **305** queries database system **315** with the alias ID to determine the actual network address linked to the alias ID. Database system **315** processes the query and returns the current network address of end system **301** to access system **305**. Access system **305** receives the response and clears the QoS requirements associated with the network address. Access system **305** responds to PDF system **311** with a success message. PDF system **311** passes the success message to proxy system **312** to complete the session termination process.

Second Embodiment Configuration and Operation—FIGS. 6-8

FIG. **6** illustrates communication network **600** in an embodiment of the invention. In this embodiment, communication network **600** allows a carrier network to retain call control over sessions originating from or terminating to a peered MSO network, even though visibility across the networks is reduced due to the presence of session border controllers. In this embodiment, a modem obtains a dynamic Internet Protocol (IP) address from a dynamic host configuration protocol (DHCP) server. The modem then registers its alias address and its dynamic IP address with a global domain name server. A SIP device connected to the modem registers with a SIP proxy server using the alias address of the modem. Upon initiating a session between the SIP device and a phone on the PSTN, the proxy server communicates with a PDF server using the alias address to configure the session QoS. The PDF server in turn communicates with a cable modem termination system (CMTS) on a cable MSO network using the alias address to provision the QoS. The CMTS queries the global DNS system to resolve the alias address of the modem to its dynamic IP address. The CMTS is then able to identify session traffic from the modem and apply the required QoS.

Communication network **600** includes cable network **660**, carrier network **670**, PSTN **680**, and hybrid fiber coax (HFC) network **650**. Devices **641**, **642**, and **643** are operatively coupled to modems **651**, **652**, and **653** respectively. Modems **651**, **652**, and **653** are operatively coupled by HFC **650** to CMTS **655**. Cable network **660** operatively couples CMTS to session border controller (SBC) **663**. SBC **663** is operatively coupled to SBC **673**. Proxy system **672**, PDF system **671**, and gateway **675** are operatively coupled together by carrier network **670** and to SBC **673**. Gateway **675** operatively couples carrier network **670** to PSTN **680**. Phone **681** is coupled to PSTN **680**. DNS system **690** is in communication with cable network **660** and carrier network through SBCs **663** and **673** respectively.

Cable network **660** could be any network typical of MSO networks. For example, cable network **600** could be a high-speed Gig-Ethernet network. HFC network **650** could be comprised of fiber links, coaxial cable links, or both. Devices **641**, **642**, and **643** could be any kind of device capable of communicating with modems **652**, **652**, and **653**. For example, devices **641**, **642**, and **643** could be computers, phones, or other types of devices. CMTS **655** could be capable of delivering data services over HFC **650** to modems **651**, **652**, and **653**. More particularly, CMTS **655** could be configured to provide QoS for services in accordance with the packet cable multimedia (PCMM) specification. CMTS **655** could communicate with modems **651**, **652**, and **653** over DOCSIS 1.1 or 2.0 links, as is well understood in the art.

SBC **663** could be any session border controller capable of controlling session traffic across the border between cable network **660** and carrier network **670**. Similarly, SBC **673** could be any session border controller capable of controlling session traffic across the border between cable network **660** and carrier network **670**. Carrier network **670** could be any network capable of providing VoP services to end users of cable network **660**. Carrier network **670** could be, for example, a packet core network capable of terminating sessions to or from cable network **660** and to or from PSTN **680**. Gateway **675** could be any gateway system capable of interfacing between carrier network **670** and PSTN **680**. Gateway **675** could be capable of interworking both bearer traffic and signaling traffic.

Proxy system **672** could be any system capable of providing call control for sessions originating from and terminating to end users in cable network **660**. For example, proxy system **672** could be a SIP proxy configured to provide call control for SIP VoP sessions originating from or terminating to devices **641**, **642**, and **643**. In another example, proxy system **672** could be configured to communicate with PDF system **671** to determine session QoS levels for individual sessions. SIP proxies are well known in the art. Proxy system **672** could also be referred to as a soft switch. Proxy system **672** could also be integrated into a soft switch. Alternatively, proxy system **672** could be a stand alone element separate from a soft switch.

PDF system **671** could be any system capable of communicating with proxy system **672** and CMTS **655** to provision session QoS. PDF system **671** could be configured to operate in accordance with the common open policy service (COPS) protocol. COPS is a standard for exchanging policy information in order to support dynamic QoS in IP networks. In this case, PDF system **671** could be considered a policy decision point (PDP), whereas CMTS **655** could be considered a policy enforcement point (PEP).

FIG. **7** is a flow diagram illustrating the operation of communication network **600** in an embodiment of the invention. To begin, modem **651** is powered on and automatically transmits an address request to DHCP server **664**. DHCP server **664** returns a dynamic IP address to modem **651**. Next, modem **651** registers the dynamic IP address and its hard-coded DNS name with DNS system **690**. The hard-coded DNS name of modem **561** could identify a phone number for the modem, the cable MSO that operates cable network **660**, and a region of the cable network in which modem **651** resides. For instance, the hard-coded address could be 7855551212.cablemso.region22. Other aliases could be used.

Next, a user using VoIP enabled device **641** desires to place a call to phone **681** on PSTN **680**. In response, device **641** transmits a SIP invite message to proxy system **672**. The invite message could identify the hard-coded modem address or ID and a destination ID for phone **681**. The destination ID could be, for example, a PSTN phone number. In response to the invite message, proxy system **672** performs call setup for the session, including transmitting a QoS request to PDF system **671**. In one example, proxy system **672** uses a SOAP/XML interface to pass along the session description protocol (SDP) information from the original invite message to PDF system **671**. The original SDP information includes the hard-coded modem address.

The PDF request indicates the hard-coded modem address. PDF system receives the QoS request and determines a QoS level for the session involving modem **651**, as identified by the hard-coded modem address. PDF system **671** transmits a quality message to CMTS **655** indicating the hard-coded modem address and the QoS level. PDF system **671** could communicate with CMTS **655** in accordance with COPS based PCMM. CCMTS **655** receives the quality message and queries DNS system **690** with the hard-coded modem address. DNS system **690** processes the query, including performing a look-up to a table based on the hard-coded modem address. DNS system **690** returns a response indicating the dynamic IP address stored in association with the hard-coded modem address. CMTS **655** then uses the dynamic IP address to identify and configure a network path for the session traffic according to the specified QoS level. Once the QoS levels have been set, CMTS **655** transmits a success message to PDF system **671**. PDF system **671** passes the success message to proxy system **672** and the session is allowed to proceed.

FIG. **8** is a flow diagram illustrating the flow of session traffic during a VoP session in communication network **600**. In one direction, device **641** transfers session traffic, such as voice data, to modem **651**. Modem **651** transfers the traffic to CMTS **655**. CMTS **655** applies the appropriate QoS, such as by prioritizing the VoP traffic over other types of non-VoP traffic. CMTS **655** then transmits the traffic to SBC **663**. SBC **663** recognizes the session traffic and passes it to SBC **673**. SBC **673** has been configured by proxy system **672** to route the traffic over carrier network **670** to gateway **675**. Gateway **675** interworks the traffic from an asynchronous packet format to a time division multiplexed (TDM) format suitable for transport over PSTN **680** to phone **681**.

In the opposite direction, session traffic, such as voice communications, is transferred from phone **681** to PSTN **680**. PSTN **680** routes the traffic to gateway **675**. Gateway **675** interworks the traffic from a TDM format to an asynchronous packet format suitable for transport over carrier network **670** to SBC **673**. SBC **673** has been configured by proxy system **672** to route the traffic to SBC **663**. Likewise, SBC **663** has been configured to route the traffic to CMTS **655**. CMTS **655** applies the appropriate QoS levels to the session traffic and forwards the traffic over HFC **650** to modem **651**. Modem **651** then provides the session traffic to device **641**. Device **641** plays out the traffic in an audio or video form suitable for a user.

The following describes the call process that occurs at the conclusion of the session. To conclude the session, end device **641** transmits a bye message to proxy system **672**. Using the SOAP/XML interface, proxy system **672** transmits the SDP information from the original invite message, including the hard-coded modem address, to PDF system **671**. Proxy system **672** also sends a request to PDF system **671** to release the QoS handling for the session. PDF system **671** receives the release request and sends a release request to CMTS **655** to release the QoS requirements. The release request indicates the hard-coded modem address for modem **651**. CMTS **655** again queries DNS system **690** to resolve the hard-coded modem address to its current dynamic IP address. Upon receiving the dynamic IP address from DNS system **690**, CMTS **655** clears the appropriate QoS gates on the data streams associated with the dynamic IP address and responds with a success message to PDF system **671**. PDF system **671** communicates the success message to proxy system **672**, and the call is successfully terminated.

Advantageously, communication network **600** allows carrier network **670** to retain call control over sessions originating from and terminating to cable network **660** even though visibility across the networks is reduced by the presence of session border controllers.

What is claimed is:

1. A communication system comprising:

a modem coupled to a cable modem termination system;

a device coupled to the modem configured to transmit an alias and a dynamic Internet Protocol (IP) address for the modem to a database, and to transmit an invite message for a session, wherein the alias identifies the device and not the dynamic IP address of the modem, and the invite message indicates a destination and the alias;

a proxy system configured to receive the invite message and transfer a quality request wherein the quality request indicates the alias;

a policy system configured to receive the quality request, determine a quality level for the session and transmit a quality message to the cable modem termination system indicating the alias and the quality level; and

the cable modem termination system configured to receive the quality message, transmit a query to the database indicating the alias, receive the dynamic IP address for the modem in response to the query, identify traffic for the session using the dynamic IP address for the modem, and apply the quality level to the traffic.

2. The communication system of claim **1** wherein the session comprises a voice over Internet Protocol (VoIP) session.

3. A method of operating a communication system, the method comprising:

transmitting an alias and a dynamic Internet Protocol (IP) address for a modem from a device coupled to the modem to a database, wherein the alias identifies the device and not the dynamic IP address of the modem;

transmitting an invite message for a session from the device coupled to the modem to a cable modem termination system, wherein the invite message indicates a destination and the alias for the device;

receiving the invite message in a proxy system and transferring a quality request from the proxy system wherein the quality request indicates the alias;

receiving the quality request in a policy system, determining a quality level for the session, transmitting a quality message to the cable modem termination system indicating the alias and the quality level; and

receiving the quality message in the cable modem termination system, transmitting a query to the database indicating the alias, receiving the dynamic IP address for the modem in response to the query, identifying traffic for the session using the dynamic IP address for the modem, and applying the quality level to the traffic.

4. The method of claim **3** wherein the session comprises a voice over Internet Protocol (VoIP) session.

* * * * *

EXHIBIT F

US005793853A

United States Patent [19]

Sbisa

[11] Patent Number: 5,793,853

[45] Date of Patent: Aug. 11, 1998

[54] **SYSTEM AND METHOD FOR RECORDING BILLING INFORMATION FOR A TELECOMMUNICATIONS SERVICE REQUEST**

[75] Inventor: **Daniel Charles Sbisa**, Blue Springs, Mo.

[73] Assignee: **Sprint Communications Co., L.P.**, Kansas City, Mo.

[21] Appl. No.: **493,438**

[22] Filed: **Jun. 22, 1995**

[51] **Int. Cl.**[6] **H04M 15/00**

[52] **U.S. Cl.** **379/120**; 379/119; 379/115; 379/230

[58] **Field of Search** 379/91, 111, 112, 379/113, 114, 115, 116, 119, 120, 121, 133, 134, 135, 201, 207, 219, 220, 222, 223, 229, 230

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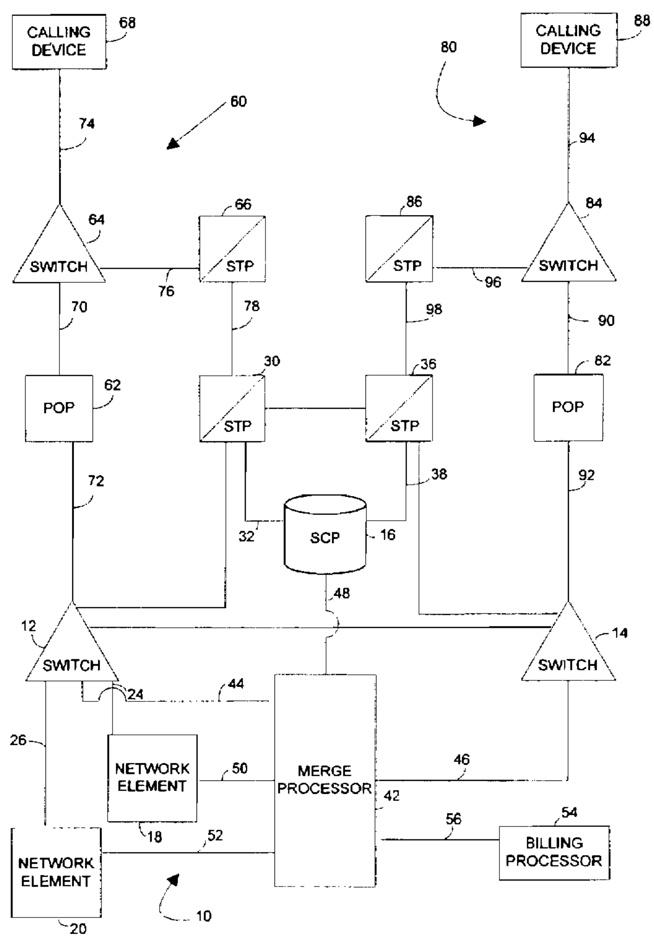
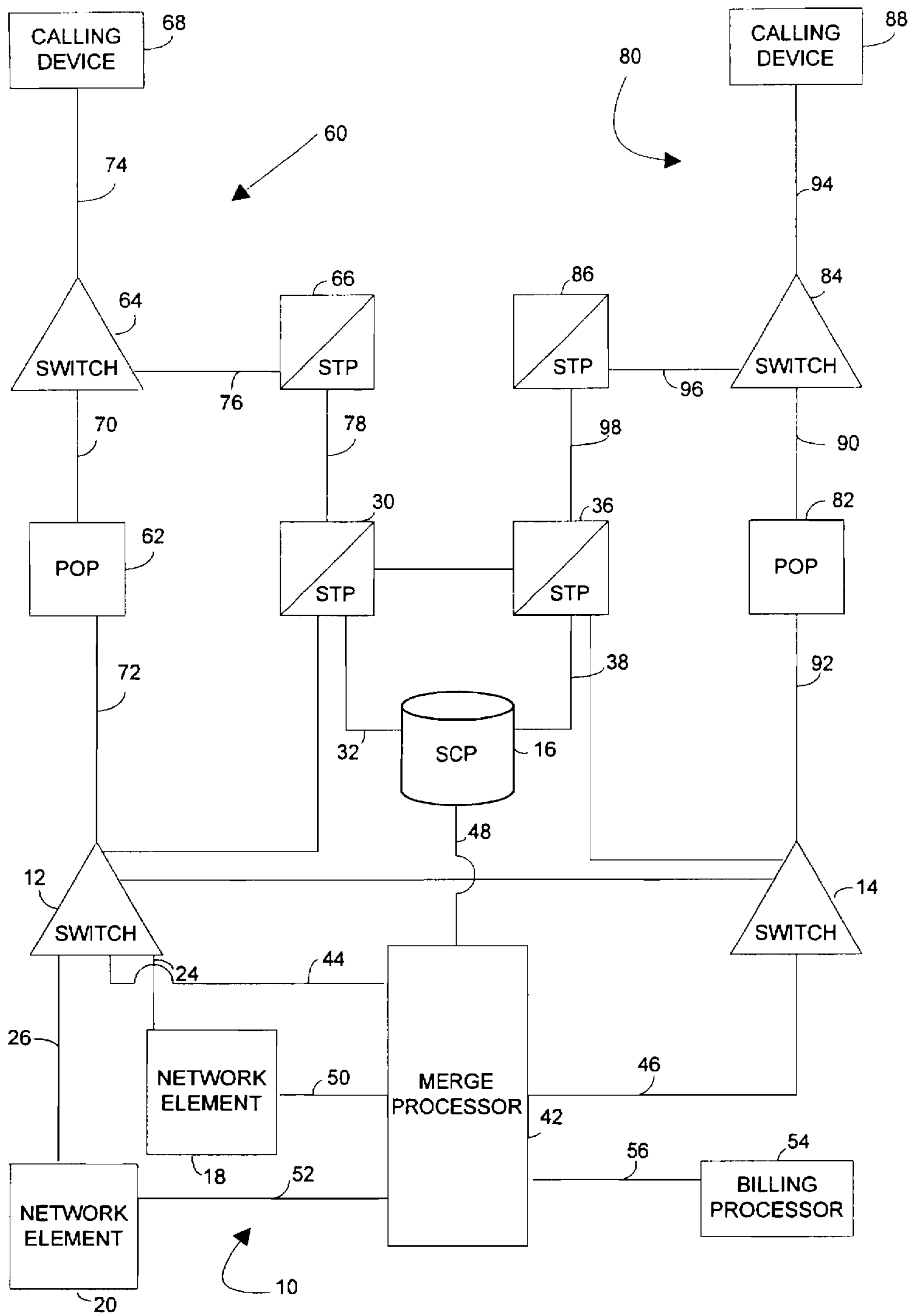
Primary Examiner—Curtis Kuntz
Assistant Examiner—Paul Loomis
Attorney, Agent, or Firm—Harley R. Ball; Jed W. Caven

[57] **ABSTRACT**

A system for recording the services provided by a telecommunications network in response to a service request generates a number of individual records corresponding to the number of network elements providing telecommunications services in response to the request. Each individual record contains information relating to the services provided by the corresponding network element. Those service requests requiring the services of two or more network elements are assigned an identifier which is stored in each corresponding record. Records having a common identifier are matched with one another and merged into a single network record corresponding to the service request. Billing statements and statistical reports may be derived from the single network record.

34 Claims, 2 Drawing Sheets





CALLING DEVICE
68
CALLING DEVICE
88
80
60
74
94
66
86
84
64
SWITCH
STP
STP
SWITCH
76
96
70
78
98
90
30
36
82
62
POP
STP
STP
POP
72
38
92
32
SCP
16
48
12
SWITCH
14
SWITCH
44
24
26
NETWORK ELEMENT
50
MERGE PROCESSOR
46
42
18
52
56
54
BILLING PROCESSOR
NETWORK ELEMENT
20
10

FIG. 1

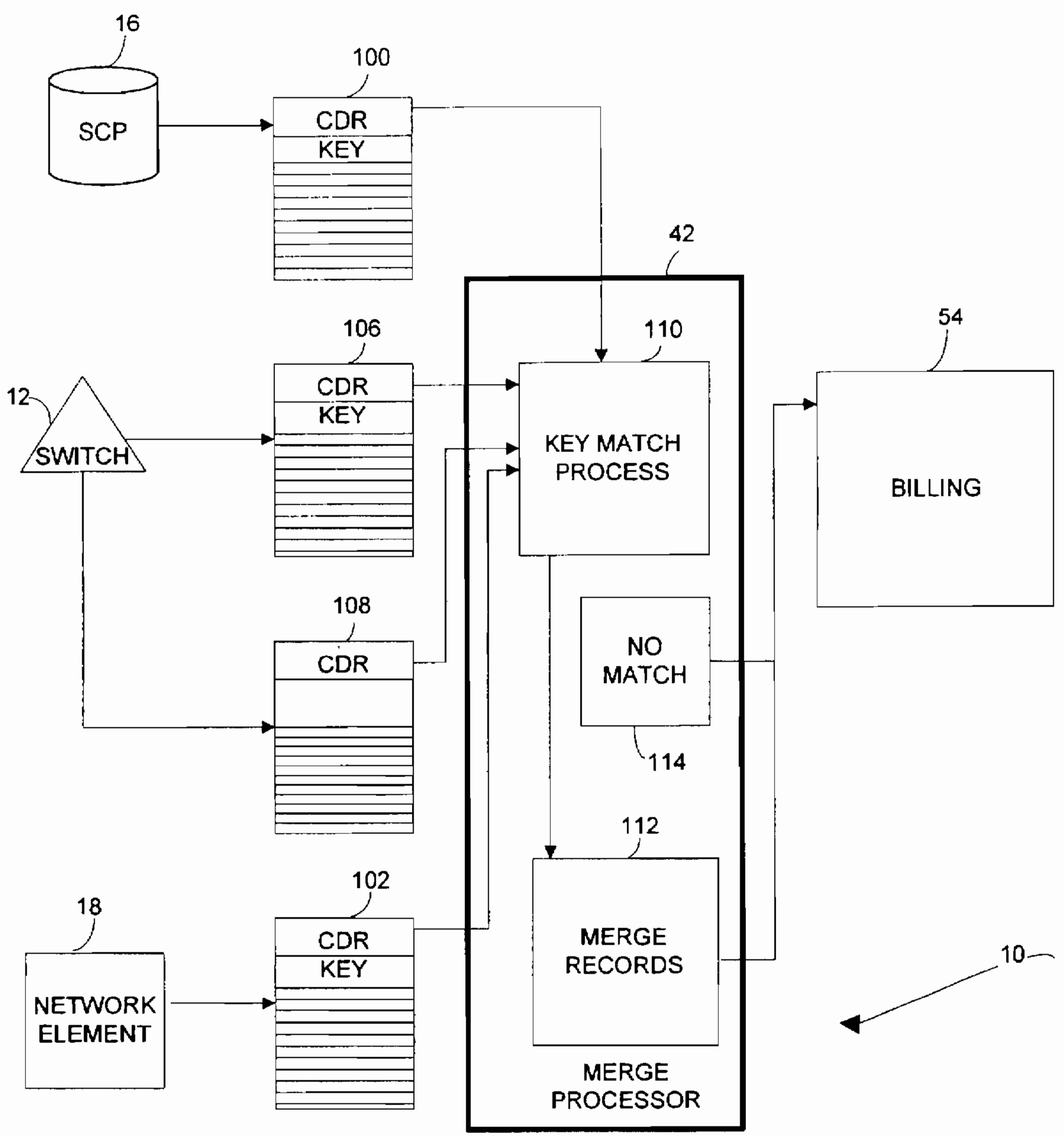

16
SCP
100
CDR
KEY
42
106
CDR
KEY
110
54
12
SWITCH
KEY MATCH
PROCESS
BILLING
108
CDR
NO
MATCH
114
112
102
18
CDR
KEY
NETWORK
ELEMENT
MERGE
RECORDS
10
MERGE
PROCESSOR

FIG. 2

SYSTEM AND METHOD FOR RECORDING BILLING INFORMATION FOR A TELECOMMUNICATIONS SERVICE REQUEST

BACKGROUND OF THE INVENTION

This invention relates in general to recording the services provided by a telecommunications network in response to a service request and, more particularly, to a system and method for processing multiple records relating to the same service request into a single network record for each request.

Telecommunications service providers generate substantial information about the services they have provided to their customers. This information is very useful for understanding the needs of their customers and for billing purposes. For example, each time a long distance telephone call is placed, the long distance carrier typically creates a call detail record (CDR) corresponding to that call. A CDR will usually include information such as the dialed number, the date and time of the call, and the duration of the call. Many enhanced services (e.g., conferencing, call allocation and 800 services) are also available and may be identified in the CDR. These enhanced services often require the services of multiple network elements to accommodate the call processing functions associated with such a request. In fact, as many as 250 items may be stored in a single CDR corresponding to a single telephone call or other telecommunications service request.

For either an 800 call or a standard long distance call, the call is first received by a local exchange carrier (LEC) and is then forwarded to the appropriate interexchange carrier (IXC). The IXC switch that receives the call from the LEC switch is referred to as the "originating switch" in the IXC network. Based on the signaling information forwarded from the LEC, the originating switch will determine where the call should be forwarded within the IXC network. Specifically, the originating switch will select a "terminating switch" that is located near the destination of the call. The originating switch may process standard long distance telephone calls without requesting the services of other network elements. However, for 800 calls, the originating switch typically queries a remote database containing routing instructions for forwarding the call to the appropriate terminating switch. Next, the terminating switch forwards the call to the appropriate LEC switch, which then completes the connection with the called party. Presently, the originating switch creates the entire CDR for the IXC network. The CDRs created by the various IXC switches are eventually forwarded to the IXC's billing system. Detailed billing statements and/or statistical analyses of caller activity may be derived from these CDRs.

One drawback to the system described above, from an IXC's point of view, is that the software controlling each telecommunications switch, and therefore controlling each originating switch, is provided by the switch vendor. Consequently, the switch vendor controls the switch software and must revise the software whenever the IXC changes its approach to billing or otherwise modifies its system. This cumbersome arrangement between the IXC and the vendor inhibits the flexibility of the IXC in operating and updating its billing system and discourages the IXC from offering new, enhanced services.

Another disadvantage associated with having an originating switch generate the entire CDR is the volume of traffic that results each time an originating switch queries another network element. For example, an originating switch may need to request information from a remote database such as a service control point (SCP) before forwarding a call to the appropriate terminating switch. The originating switch queries the SCP using a protocol that facilitates communication between the two devices. The SCP responds to the query by sending the requested information back to the originating switch using the designated protocol (e.g., SS7, TCP/IP or ISDN). Because these types of transactions occur frequently in a typical IXC network, communications links between the switches and the other network elements often become congested with numerous queries and responses. Moreover, each link has physical limitations regarding the quantity of data it can transmit, so the traffic over the link must not exceed the capacity of the link.

The problem with congested communications links is particularly acute where the response to the originating switch includes billing information as opposed to call routing information. Operator centers, for example, provide such service functions as collect calling, conferencing, and foreign language interpretation. When the originating switch passes service control to an operator center, the operator center primarily generates billing information related to the services provided. Such billing information is generally not used by the originating switch for processing the call.

SUMMARY OF THE INVENTION

The present invention is directed to a system and method for generating a single network record for telecommunications services provided in response to a service request. The invention overcomes the problems and limitations set forth above by creating individual records associated with the services provided by each individual network element in response to a service request, then combining these individual records into a single network record corresponding to the service request. This arrangement permits the IXC to provide and control the software for creating and processing the CDRs since the IXC typically controls the communications between network elements. Thus, the IXC is no longer dependent on a vendor to implement software revisions. As a result, the IXC will have increased flexibility in billing its customers for special services. Rather than charging a flat fee for subscribing to optional services (e.g., time of day routing), the IXC is in a position to offer its customers usage-based fees derived from the individual records generated by each network element.

Further, communications traffic between the network elements is greatly reduced because the other network elements are no longer required to transmit billing information back to the originating switch. Rather, a first network element receives the service request and generates an individual record corresponding to the services it provides in response to the request. Then, the first network element sends a message to any additional network element that will provide services in response to the service request. These additional network elements will create their own individual records relating to the services provided in response to the request, but the additional network elements will not need to transmit any billing information or records back to the first network element. Therefore, substantial efficiencies are achieved in the communications protocols linking the various network elements.

Accordingly, it is an object of the present invention to provide a system and method for creating a single network record containing information relating to the services provided by a telecommunications network in response to a service request wherein the telecommunications carrier controls the communications software.

It is a further object of the present invention to provide a system and method for generating a single network record containing information relating to the services provided by a telecommunications network in response to a service request so that congestion is substantially reduced in the communications links connecting the various network elements.

It is yet a further object of the present invention to provide a system and method for generating a single network record containing information relating to the services provided by a telecommunications network in response to a service request wherein each network element providing services creates an individual record relating to the services provided by that network element in response to the request.

These and other related objects of the present invention will become readily apparent upon further review of the specification and drawings. To accomplish the objects of the present invention, a system for recording the services provided by a telecommunications network in a single network record is provided which has a first network element for generating individual records containing information related to the services provided by the first network element in response to a service request, at least one additional network element for generating individual records containing information relating to the services provided by the additional network elements in response to the service request, means for assigning a key identifier to the individual records corresponding to those service requests requiring services from more than one network element, and a record processor which receives the individual records, compares the key identifiers, and merges the individual records having the same key identifier into a single network record.

In another aspect, a method for recording the services provided by a telecommunications network in a single record is provided which includes receiving service requests requiring the services of at least one network element, generating a first record for each service request containing information relating to the services provided by a first network element in response to the request, generating a number of additional records each relating to the services provided by an additional element in response to the service request, matching each first record with any additional records corresponding to the same service request, and processing all of the records so that the information relating to the services provided by the telecommunications network in response to each service request is contained in a single network record corresponding to that service request.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form a part of the specification and are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

FIG. 1 is a block diagram showing an interexchange carrier network coupled with first and second local exchange carrier networks in accordance with the preferred embodiment of the present invention;

FIG. 2 is a flow diagram illustrating the method of generating and processing call detail records in accordance with the preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in greater detail, and initially to FIG. 1, the telecommunications network of the present

invention is designated generally by reference numeral **10**. Network **10** comprises a plurality of network elements such as telecommunications switches **12** and **14**, a service control point (SCP) **16**, and additional network elements **18** and **20**. Switch **12** is connected to switch **14** via a communications link **22**, and switch **12** is connected to additional elements **18** and **20** by links **24** and **26**, respectively. Switch **12** is connected to SCP **16** through a link **28**, a signal transfer point (STP) **30** and a link **32**. Likewise, switch **14** is coupled with SCP **16** via a link **34**, a STP **36**, and a link **38**. A link **40** couples STP **30** and STP **36**.

Network **10** also includes a merge processor **42** coupled to switch **12** via a link **44** and to switch **14** via a link **46**. Further, processor **42** is coupled to network elements **16**, **18** and **20** via links **48**, **50** and **52**, respectively. Finally, network **10** includes a billing processor **54** connected to merge processor **42** by a link **56**.

Although network **10** is an IXC network in the disclosed embodiment, in another embodiment network **10** could be a LEC network or any other network providing telecommunications services. In the preferred embodiment, IXC network **10** is coupled to a first LEC network **60** at an IXC point of presence (POP) **62**. LEC network **60** includes a switch **64**, a STP **66** and a plurality of individual calling terminals such as terminal **68**. LEC switch **64** is connected to IXC switch **12** via a link **70**, a POP **62** and a link **72**. A link **74** represents the connection between LEC switch **64** and terminal **68**. STP **66** is connected to switch **64** by a link **76** and to STP **30** via a link **78**.

IXC network **10** is also coupled with a second LEC network **80** via a POP **82**. Network **80** includes a switch **84**, a STP **86** and a plurality of individual terminals such as terminal **88**. Switch **84** is coupled to IXC switch **14** via a link **90**, a POP **82** and a link **92**. A link **94** represents the connection between LEC switch **84** and the terminal **88**. STP **86** is coupled with switch **84** via a link **96** and with IXC STP **36** via a link **98**.

Those skilled in the art will readily appreciate that the specific components of network **10**, network **60** and network **80** may vary somewhat from the disclosed embodiment without significantly deviating therefrom. Moreover, many of the identified components may exist in a variety of forms in a given telecommunications network. For example, terminals **68** and **88** may be voice terminals (e.g., a telephone) and/or data terminals (e.g., a computer). Likewise, those skilled in the art will recognize that additional network elements **18** and **20** may be any network element adapted to provide telecommunications services in response to a service request. For example, element **18** could be a generic service platform (e.g., an intelligent peripheral) or an enhanced services platform. Likewise, element **20** could be a telecommunications switch, a SCP, a STP, a POP, or an operator center. The specific embodiment of elements **18** and **20** may affect the selection of a protocol for communicating with the other network elements but will not significantly depart from the preferred embodiment described herein.

With reference to FIG. 2, network **10** is depicted in a flow diagram. As network element **16** provides telecommunications services in response to a service request, a CDR **100** is developed containing information relating to the specific services provided by element **16**. Similarly, element **18** generates a CDR **102** containing information relating to the specific services provided by element **18** in response to a service request. However, element **12** may generate either a CDR **106** containing information relating a portion of the services provided by the network (e.g., relating to only those services provided by element 12) in response to a service request, or element 12 may produce a CDR 108 containing information relating to all of the services provided by any network element in response to a service request.

In operation, network 10 may receive a plurality of service requests including some service requests which require the services of more than one network element. Each service request received by network 10 is initially forwarded to a first network element. Although the first network element might not be the same network element for every service request, element 12 is treated as the first network element in the disclosed embodiment. As each service request is processed, switch 12 generates a corresponding CDR similar to CDR 108. If the service request does not require the services of any other network element, then switch 12 will have generated the entire CDR for that request and will forward the CDR (CDR 108) to merge processor 42 via link 44.

On the other hand, if switch 12 determines that the service request requires the services of another network element, switch 12 sends an appropriate message to the other network element. If the service request requires the services of both switch 12 and SCP 16, for example, switch 12 sends a message to SCP 16 identifying the requested services. SCP 16 then creates a CDR similar to CDR 100 and assigns an identification key to be stored in that CDR. As described more fully below, the identification key includes both a network element code and a key identifier corresponding to the service request. SCP 16 may acknowledge receipt of the message from switch 12 by transmitting the key identifier and any necessary routing information back to switch 12.

The carrier-controlled communications software is designed so that the key identifier can be forwarded to any network element independent of the particular protocol established between any two network elements. After the key identifier is forwarded to switch 12, the switch stores the identifier in the switch CDR corresponding to the service request as shown in FIG. 2 (CDR 106). After the service request has been processed, the CDR created by SCP 16 (CDR 100) and the CDR created by switch 12 (CDR 106) are forwarded to merge processor 42. Likewise, the service request may also require the services of additional element 18, which will therefore generate its own CDR containing the appropriate key identifier as shown in FIG. 2 (CDR 102). Then, CDR 102 is forwarded to merge processor 42 via link 50.

The means for assigning an identification key to the individual records corresponding to a service request requiring services from a plurality of network elements could be located anywhere in network 10. In the disclosed embodiment, switch 12 is the first network element to receive a service request. Thus, switch 12 is the "primary network element" for a service request from terminal 68 requiring the services of multiple network elements. As such, switch 12 could assign an identification key to every service request and forward the key identifier to the additional network elements as needed, or switch 12 could assign an identification key only for those service requests invoking the services of two or more network elements.

In the preferred embodiment, however, an additional network element actually assigns the identification key in response to a message from switch 12 and then forwards the key identifier to switch 12 as an acknowledgment that the message has been received. Further, it is presently preferred to use a nine-digit identification key wherein the first three digits identify a specific network element and the last six

digits are a key identifier generated by a counter device which is incremented for each service request requiring services from a plurality of network elements. For example, a single service request requiring the services of switch 12, SCP 16 and element 18 may be assigned the following identification keys: 012000001, 016000001, and 018000001. Similar methods and devices for assigning an identification key to the CDRs will be readily apparent to those skilled in the art.

The present invention provides several advantages over the prior art. First, the IXC controls the software for communications between network elements and therefore controls the billing software. Consequently, the IXC is not dependent on the switch vendor for making software revisions. Second, the IXC may present its customers with more flexible billing options. Instead of a flat subscription fee, IXC customers may prefer usage-based fees such as a variable rate based on the level of usage or a predetermined fee for each individual call that requires the special service. Additionally, the individual records generated by the additional network elements enable the IXC to provide its customers with a detailed statistical analysis of the customers' call history. Finally, communications traffic between the network elements is significantly reduced. Rather than transmitting billing information from each secondary network element to the primary network element before it is forwarded to the merge processor, the billing information may be sent directly to the merge processor from the secondary network elements. Advantageously, this arrangement should result in increased traffic handling capacity for the IXC network.

As shown in FIG. 2, merge processor 42 includes a key match process 110 wherein CDRs having the same key identifier (i.e., same last six digits of identification key) are matched with one another. The matched records are forwarded from process 110 to a merge records area 112. It is presently preferred to append any records created by a secondary or additional network element to the record created by the first or primary network element at block 112. The merge process may exclude or delete certain information from the appended records if the information is redundant or no longer relevant. For example, if CDR 100 includes an initial list of several alternative network routes, those routes that were not actually used may be deleted during the merge process so that the length of the merged record is reduced.

Those records that are not matched with any other records during the key match process (e.g., CDR 108) are forwarded to no match buffer 114. Finally, all of the records in buffer 114 and all of the merged records at block 112 are forwarded to the billing processor 54 via link 56.

Although switch 12 is referred to above as the "primary network element," it will be appreciated that switch 14 would be the primary network element, in accordance with the preferred embodiment of the invention, for calls originating from terminal 88. Switches 12 and 14 are preferably DMS-250 telecommunications switches manufactured by Northern Telecom. Those skilled in the art will appreciate that network elements 16, 18 or 20 could also act as the primary network element for certain service requests.

From the foregoing, it will be seen that this invention is one well adapted to attain all the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, we claim:

1. In a telecommunications network including a plurality of network elements, a method for recording information relating to the services provided by the telecommunications network in response to a telecommunications service request requiring the services of a primary network element and at least one secondary network element, said method comprising:

generating a primary record containing information relating to the services provided by a primary network element in response to the request and an identification key;

transmitting the primary record from the primary network element to a separate network element including a merge processor;

generating at least one secondary record, wherein each secondary record contains information relating to the services provided by a secondary network element in response to the service request and an identification key containing information associating the secondary record with the primary record;

transmitting the at least one secondary record from the secondary network element to the merge processor;

comparing the identification keys of records received at the merge processor; and

merging associated primary and secondary records to form a single network record containing information relating to the services provided by the primary and secondary network elements in response to the request.

2. The method of claim 1, wherein a plurality of secondary records are generated by a plurality of secondary network elements.

3. The method of claim 1, wherein the primary record is generated by the primary network element.

4. The method of claim 3, wherein the primary network element includes a telecommunications switch.

5. The method of claim 1, wherein each secondary record is generated by a secondary network element.

6. The method of claim 5, wherein at least one secondary network element includes a generic service platform.

7. The method of claim 5, wherein at least one secondary network element includes a service control point.

8. The method of claim 5, wherein at least one secondary network element includes an enhanced services platform.

9. The method of claim 5, wherein at least one secondary network element includes an operator center.

10. A method for recording in a single network record the services provided by a telecommunications network responsive to a service request, wherein the telecommunications network includes a plurality of network elements, said method comprising:

generating a primary record for each service request, each primary record containing information relating to the services provided by a primary network element in response to the corresponding service request;

transmitting the primary record from the primary network element to a separate network element including a merge processor;

generating at least one secondary record for each service request, each secondary record containing information relating to the services provided by a secondary network element in response to the corresponding service request and an identification key;

transmitting the at least one secondary record from the secondary network element to the merge processor;

matching each primary record with any secondary records generated in response to the same service request; and

processing the primary and secondary records so that the information relating to the services provided by each of the network elements in response to a service request is contained in a single network record corresponding to that service request.

11. The method of claim 10, wherein the number of secondary records generated for at least one service request is greater than or equal to one.

12. The method of claim 10, wherein the secondary records corresponding to the same service request are assigned the same identification key.

13. The method of claim 12, wherein the matching step further comprises matching primary and secondary records containing the same identification key.

14. The method of claim 13, wherein identification keys are assigned by a counter.

15. The method of claim 10, wherein the primary network element includes a telecommunications switch.

16. The method of claim 10, wherein each secondary record is generated at a secondary network element.

17. The method of claim 10, wherein the secondary network element comprises a generic service platform.

18. The method of claim 10, wherein the secondary network element comprises a service control point.

19. The method of claim 10, wherein the secondary network element comprises an enhanced services platform.

20. The method of claim 11, wherein the secondary network element comprises an operator center.

21. The method of claim 10, wherein the processing step further includes merging the primary and secondary records corresponding to the same service request into a single network record by appending each additional record to the corresponding first record.

22. The method of claim 10, wherein the processing step further includes deleting a portion of the information contained in the primary record.

23. The method of claim 10, wherein the processing step further includes deleting a portion of the information contained in a secondary record.

24. A system for generating one or more records for recording information relating to the services provided by a telecommunications network in response to a service request, wherein the telecommunications network includes a plurality of network elements, said system comprising:

a primary network element adapted to generate a primary record in response to a service request, the primary record containing information relating to the services provided by the primary network element in response to the corresponding service request;

at least one secondary network element adapted to generate a secondary record, in response to a service request, the secondary record containing information relating to the services provided by the secondary network element in response to the corresponding service request;

means for assigning an identification key to the primary and secondary records, the identification key including information for associating the primary and secondary records; and a third network element separate from the primary network element and the secondary network element adapted to receive records from the primary network element and the secondary network element and comprising means for comparing the identification keys assigned to the records and means for merging associated records.

25. The system of claim **24**, wherein the primary network element comprises a telecommunications switch.

26. The system of claim **24**, wherein a secondary network element comprises a generic service platform.

27. The system of claim **24**, wherein a secondary network element comprises a service control point.

28. The system of claim **24**, wherein a secondary network element comprises an enhanced services platform.

29. The method of claim **24**, wherein a secondary network element comprises an operator center.

30. The system of claim **24**, wherein each assigned identification key is stored in the corresponding records.

31. The system of claim **24**, wherein said assigning means includes a counter.

32. The system of claim **24**, wherein the third network element comprises a merge processor which receives the records, compares the identification key assigned to the records, and merges the records assigned the same identification key into a single network record.

33. The system of claim **24**, wherein only those individual records containing an assigned identification key are merged with any other records.

34. The system of claim **32**, wherein the merge processor deletes a portion of the information contained in the individual records.

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