

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

INVALIDITY CLAIM CHART

Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

U.S. Patent No. 7,352,703 (“Elie-Dit-Cosaque”) was published on November 4, 2004, from an application filed on April 29, 2003. Elie-Dit-Cosaque therefore constitutes prior art under at least 35 U.S.C. §§ 102(a), 102(b) and 102(e). Elie-Dit-Cosaque anticipates and/or renders obvious the Asserted Claims of the U.S. Patent No. 8,982,691, either alone or in combination with one or more of the references identified in Defendant’s Cover Pleading.

To the extent WSOU argues that any element below is not disclosed by Elie-Dit-Cosaque, a person of ordinary skill in the art would have found it obvious to combine the teachings of Elie-Dit-Cosaque with the background knowledge of a person of ordinary skill in the art and/or the additional references, and exemplary teachings, set forth in Appendix D.

The chart below provides representative examples of where each element of each claim is found within Elie-Dit-Cosaque. Citations are meant to be exemplary, not exhaustive, and Defendant reserves the right to identify and discuss additional portions of the reference in support of its contentions and/or to rebut arguments made by WSOU. Citations to figures, drawings, tables, and the like include reference to any accompanying or related text. All internal cross references are meant to incorporate the cross-referenced material as if fully set forth therein.

It is Defendant’s position that WSOU’s Preliminary Infringement Contentions have not established that any accused product or service infringes any valid claim. Thus, Defendant’s statements below should not be treated as an admission, implication, or suggestion that Defendant agrees with WSOU regarding either the scope, construction, or interpretation of any of the Asserted Claims or the infringement theories advanced by WSOU in its Preliminary Infringement Contentions, including whether any Asserted Claim satisfies 35 U.S.C. §§ 101 or 112. In certain cases, Defendant specifies non-limiting examples of where its application of the prior art is based on WSOU’s apparent application of the claim element. These statements are not intended to suggest that Defendant agrees with WSOU’s application of any claim term, suggest a proposed construction at this stage of the case, or suggest that construction is needed, as the parties are not required to exchange terms for construction or proposed constructions until a later date.

WSOU has yet to identify any limitation of the Asserted Claims that it contends is not anticipated and/or rendered obvious by Elie-Dit-Cosaque. Defendant therefore expressly reserves the right to respond to any such contention, including by identifying additional obviousness combinations, if WSOU makes any such contention.

Where Defendant states that Elie-Dit-Cosaque “discloses” a limitation, that disclosure may be express, implicit, and/or inherent.

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
[1pre] A method performed by a network processor of a Multiprotocol Label Switching (MPLS) label switch router for providing a Backup Label Switched Path (LSP) to a Bypass LSP already established for a Protected Primary LSP, the method comprising the steps of:	To the extent the preamble is limiting, Elie-Dit-Cosaque discloses a method performed by a network processor of a Multiprotocol Label Switching (MPLS) label switch router for providing a Backup Label Switched Path (LSP) to a Bypass LSP already established for a Protected Primary LSP. <i>See, e.g.:</i> Protection scheme for a communications network under multiple failures. Title. A system and method for implementing a shared protection scheme under a scenario of multiple failures in an optical network. In one embodiment of the invention, a working path between an ingress node and an egress node is computed responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointedness, as well as resource-based cost constraints. Abstract. A network operator typically takes into consideration multiple objectives when routing traffic through a network. One objective may be to minimize cost. Another objective may be to minimize transmission impairments. A third objective may be to maximize the possibility that the network can be restored using a backup path in the event of a failure thereof. Generally, there are three types of restoration schemes: dedicated restoration, shared restoration, and best effort restoration. In dedicated restoration, the capacity of a protection, or restoration, path is reserved for an individual demand. In shared restoration, the restoration capacity is reserved, but shared across multiple demands. In best effort restoration, no reservation is made and restoration capacity is allocated in real time on an as-available basis. The first two classes of restoration both have guaranteed restoration in the event of a single failure; however, they differ in restoration time, as shared restoration requires real-time path setup. Whereas intelligent mesh routing techniques have been available for computing a backup path in a 1:N or M:N shared restoration scheme, such techniques tend to be inadequate where multiple failures are encountered in a network. Further, known protection path implementations do not address the issue of correlated multiple failures, especially in the context of applicable network resource constraints. 1:25–50

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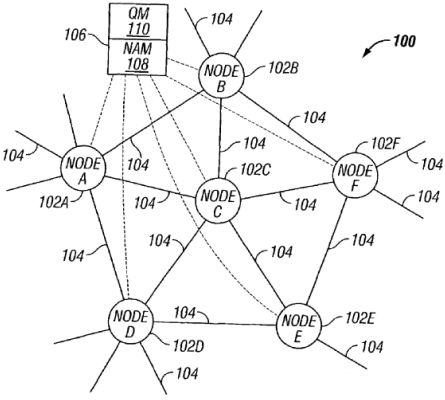
Claim	Disclosure
	Accordingly, the present invention advantageously provides a system and method for implementing a shared protection scheme under a scenario of multiple failures in a network. In one aspect, the present invention is directed to a method for providing protection in a communications network including a plurality of nodes coupled by communication links. The method commences by computing a working path between an ingress node and an egress node responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointness, as well as resource-based cost constraints in an exemplary implementation. Setup messages regarding the working path and the backup paths are then transmitted to the nodes spanning the paths. In one exemplary embodiment, the backup paths are computed using a methodology wherein the links between two backup paths or between a backup path and the working path are completely disjoint. In another exemplary embodiment, the backup and working paths may be partially disjoint in term of the links. In a further exemplary embodiment, both links as well as nodes may be completely or partially disjoint between the working path and backup paths. As a further variation, the backup path implementation may be activated based on network quality, wherein nodal and/or link quality degradation may be monitored for determining a failure condition arising out of temporal or spatial correlation of degradation events. 1:54–2:15  FIG. 1 Fig. 1

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Claim	Disclosure
	Referring now in particular to FIG. 1, depicted therein is an exemplary optical transport network 100 wherein a protection scheme involving multiple backup paths may be implemented in accordance with the teachings of the present invention. The optical transport network 100, which may be implemented as a generalized multi-protocol label switched (GMPLS) optical transport network, includes a plurality of nodes or network elements 102A through 102F coupled by optical links 104. An optical link 104 is effectuated as a fiber carrying information between two nodes; for example, between Node A 102A and Node D 102D. The optical fiber is operable to carry information over a number of wavelengths or “channels”, effectuated by means of such well-known techniques as wavelength division multiplexing (WDM) or dense WDM (DWDM), wherein different channels of information are modulated using respective frequencies or wavelengths. The number of wavelengths, N, is dependent on implementation and may be different for each fiber. As the optical links 104 are unidirectional, typically a pair of links are disposed between any two adjacent nodes in order to facilitate bidirectional transport therebetween, each node receiving information on one link and transmitting information on the other link. It will be apparent that for purposes of illustration only one link is shown in FIG. 1, it being understood that at least one link in each direction would normally be used in an actual implementation. When information is received by an edge node (i.e., an ingress node) of the transport network 100, a path is computed between the ingress node and the destination node from which the information is to exit the transport network (i.e., the egress node). Thus, a path may be treated as a sequential concatenation of a number of links spanning between the ingress and egress nodes. By way of convention, a path may be designated as string of nodes disposed between the originating and destination nodes. For instance, the ordered sequence {A,D,C,F} designates a path between Node A as the ingress node and Node F as the egress node, Nodes D and C being intermediary nodes. 3:13–51 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and

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	temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12 300A <table><tr><th colspan="3">SHARED PROTECTION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>WORKING PATH(S)</th></tr><tr><td>AB</td><td>1</td><td>{A,B,D,F}</td></tr><tr><td>AB</td><td>2</td><td>{A,B}</td></tr><tr><td>AB</td><td>3</td><td></td></tr><tr><td>AB</td><td>4</td><td>{A,C,D,F}</td></tr><tr><td>AB</td><td>5</td><td>{A,C,E} {B,D,F}</td></tr><tr><td>AB</td><td>6</td><td>{Q,R,S}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>{A,C}</td></tr><tr><td>AC</td><td>2</td><td>{A,B,D,F}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> 300B <table><tr><th colspan="3">LINK ALLOCATION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>STATUS</th></tr><tr><td>AB</td><td>1</td><td>IN USE</td></tr><tr><td>AB</td><td>2</td><td>IN USE</td></tr><tr><td>AB</td><td>3</td><td>AVAILABLE</td></tr><tr><td>AB</td><td>4</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>AVAILABLE</td></tr><tr><td>AC</td><td>2</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3A FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed	SHARED PROTECTION TABLE			LINK	CHANNEL/(FIBER)	WORKING PATH(S)	AB	1	{A,B,D,F}	AB	2	{A,B}	AB	3		AB	4	{A,C,D,F}	AB	5	{A,C,E} {B,D,F}	AB	6	{Q,R,S}	⋮	⋮	⋮	AC	1	{A,C}	AC	2	{A,B,D,F}	⋮	⋮	⋮	LINK ALLOCATION TABLE			LINK	CHANNEL/(FIBER)	STATUS	AB	1	IN USE	AB	2	IN USE	AB	3	AVAILABLE	AB	4	SHARED	⋮	⋮	⋮	AC	1	AVAILABLE	AC	2	SHARED	⋮	⋮	⋮
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Claim	Disclosure
	when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration, for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 <pre> graph TD 402[402 RECEIVING CONNECTION REQUEST] --> 404[404 COMPUTING A WORKING PATH] 404 --> 406[406 COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[408 TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4

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Claim	Disclosure
	In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10 FIG. 5A FIG. 5B FIG. 5C FIG. 5D FIG. 5E

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Claim	Disclosure
	Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations.

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	Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

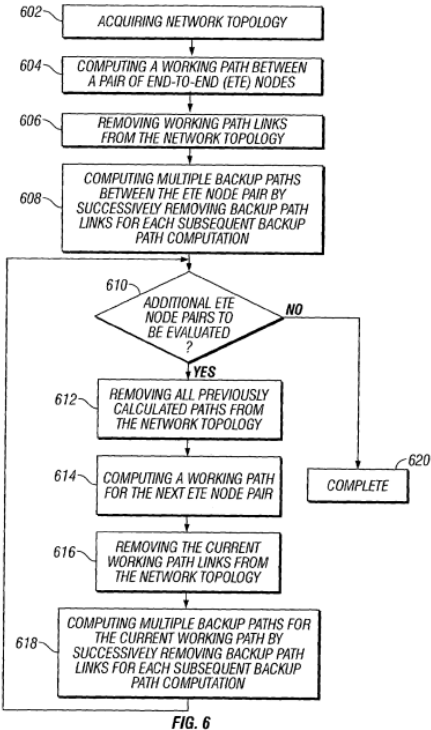
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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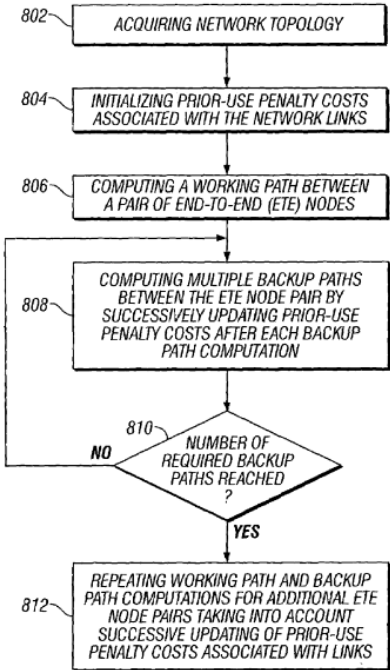
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED ?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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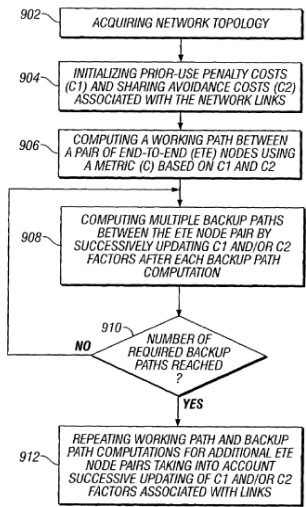
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4 <pre> graph TD 1002[MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> The flowchart, labeled FIG. 10, consists of four rectangular boxes arranged vertically and connected by downward-pointing arrows. The first box is labeled 1002 and contains the text 'MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER'. The second box is labeled 1004 and contains 'DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT'. The third box is labeled 1006 and contains 'MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT'. The fourth box is labeled 1008 and contains 'APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION'. FIG. 10

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	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[1a] protecting the Primary LSP against dual failures, comprising:	Elie-Dit-Cosaque discloses protecting the Primary LSP against dual failures. <i>See, e.g.:</i>

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	Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one

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	backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18 Protection scheme for a communications network under multiple failures. Title.

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Claim	Disclosure
	A system and method for implementing a shared protection scheme under a scenario of multiple failures in an optical network. In one embodiment of the invention, a working path between an ingress node and an egress node is computed responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointedness, as well as resource-based cost constraints. Abstract. A network operator typically takes into consideration multiple objectives when routing traffic through a network. One objective may be to minimize cost. Another objective may be to minimize transmission impairments. A third objective may be to maximize the possibility that the network can be restored using a backup path in the event of a failure thereof. Generally, there are three types of restoration schemes: dedicated restoration, shared restoration, and best effort restoration. In dedicated restoration, the capacity of a protection, or restoration, path is reserved for an individual demand. In shared restoration, the restoration capacity is reserved, but shared across multiple demands. In best effort restoration, no reservation is made and restoration capacity is allocated in real time on an as-available basis. The first two classes of restoration both have guaranteed restoration in the event of a single failure; however, they differ in restoration time, as shared restoration requires real-time path setup. Whereas intelligent mesh routing techniques have been available for computing a backup path in a 1:N or M:N shared restoration scheme, such techniques tend to be inadequate where multiple failures are encountered in a network. Further, known protection path implementations do not address the issue of correlated multiple failures, especially in the context of applicable network resource constraints. 1:25–50 Accordingly, the present invention advantageously provides a system and method for implementing a shared protection scheme under a scenario of multiple failures in a network. In one aspect, the present invention is directed to a method for providing protection in a communications network including a plurality of nodes coupled by communication links. The method commences by computing a working path between an ingress node and an egress node responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointedness, as well as resource-based cost constraints in an exemplary implementation. Setup messages regarding the

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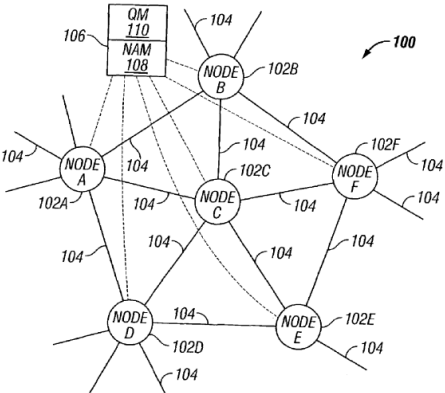
Claim	Disclosure
	working path and the backup paths are then transmitted to the nodes spanning the paths. In one exemplary embodiment, the backup paths are computed using a methodology wherein the links between two backup paths or between a backup path and the working path are completely disjoint. In another exemplary embodiment, the backup and working paths may be partially disjoint in term of the links. In a further exemplary embodiment, both links as well as nodes may be completely or partially disjoint between the working path and backup paths. As a further variation, the backup path implementation may be activated based on network quality, wherein nodal and/or link quality degradation may be monitored for determining a failure condition arising out of temporal or spatial correlation of degradation events. 1:54–2:15  FIG. 1 Fig. 1 Referring now in particular to FIG. 1, depicted therein is an exemplary optical transport network 100 wherein a protection scheme involving multiple backup paths may be implemented in accordance with the teachings of the present invention. The optical transport network 100, which may be implemented as a generalized multi-protocol label switched (GMPLS) optical transport network, includes a plurality of nodes or network elements 102A through 102F coupled by optical links 104. An optical link 104 is effectuated as a fiber carrying information between two nodes; for example, between Node A 102A and Node D 102D. The optical fiber is operable to carry information over a number of wavelengths or “channels”, effectuated by means of such well-known techniques as wavelength division multiplexing (WDM) or dense WDM (DWDM), wherein

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	different channels of information are modulated using respective frequencies or wavelengths. The number of wavelengths, N, is dependent on implementation and may be different for each fiber. As the optical links 104 are unidirectional, typically a pair of links are disposed between any two adjacent nodes in order to facilitate bidirectional transport therebetween, each node receiving information on one link and transmitting information on the other link. It will be apparent that for purposes of illustration only one link is shown in FIG. 1, it being understood that at least one link in each direction would normally be used in an actual implementation. When information is received by an edge node (i.e., an ingress node) of the transport network 100, a path is computed between the ingress node and the destination node from which the information is to exit the transport network (i.e., the egress node). Thus, a path may be treated as a sequential concatenation of a number of links spanning between the ingress and egress nodes. By way of convention, a path may be designated as string of nodes disposed between the originating and destination nodes. For instance, the ordered sequence {A,D,C,F} designates a path between Node A as the ingress node and Node F as the egress node, Nodes D and C being intermediary nodes. 3:13–51 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12

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Claim	Disclosure																																																																		
	300A <table><tr><th colspan="3">SHARED PROTECTION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>WORKING PATH(S)</th></tr><tr><td>AB</td><td>1</td><td>{A,B,D,F}</td></tr><tr><td>AB</td><td>2</td><td>{A,B}</td></tr><tr><td>AB</td><td>3</td><td></td></tr><tr><td>AB</td><td>4</td><td>{A,C,D,F}</td></tr><tr><td>AB</td><td>5</td><td>{A,C,E} {B,D,F}</td></tr><tr><td>AB</td><td>6</td><td>{Q,R,S}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>{A,C}</td></tr><tr><td>AC</td><td>2</td><td>{A,B,D,F}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3A 300B <table><tr><th colspan="3">LINK ALLOCATION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>STATUS</th></tr><tr><td>AB</td><td>1</td><td>IN USE</td></tr><tr><td>AB</td><td>2</td><td>IN USE</td></tr><tr><td>AB</td><td>3</td><td>AVAILABLE</td></tr><tr><td>AB</td><td>4</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>AVAILABLE</td></tr><tr><td>AC</td><td>2</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration, for a high quality class of service, a working path may not be used using 1+1 protection, where	SHARED PROTECTION TABLE			LINK	CHANNEL/(FIBER)	WORKING PATH(S)	AB	1	{A,B,D,F}	AB	2	{A,B}	AB	3		AB	4	{A,C,D,F}	AB	5	{A,C,E} {B,D,F}	AB	6	{Q,R,S}	⋮	⋮	⋮	AC	1	{A,C}	AC	2	{A,B,D,F}	⋮	⋮	⋮	LINK ALLOCATION TABLE			LINK	CHANNEL/(FIBER)	STATUS	AB	1	IN USE	AB	2	IN USE	AB	3	AVAILABLE	AB	4	SHARED	⋮	⋮	⋮	AC	1	AVAILABLE	AC	2	SHARED	⋮	⋮	⋮
SHARED PROTECTION TABLE																																																																			
LINK	CHANNEL/(FIBER)	WORKING PATH(S)																																																																	
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Claim	Disclosure
	sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 <pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received

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Claim	Disclosure
	at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

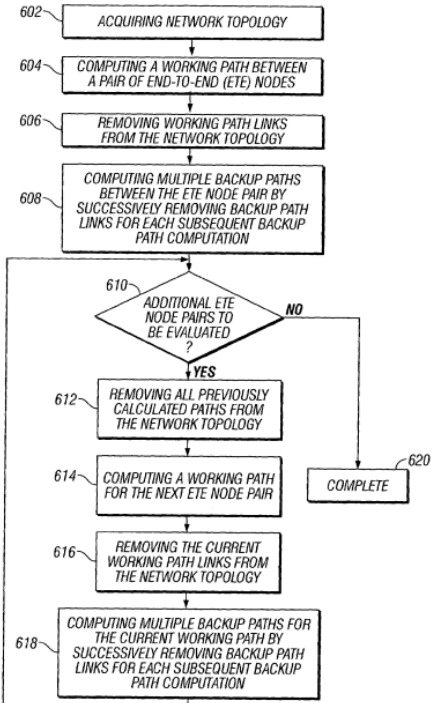
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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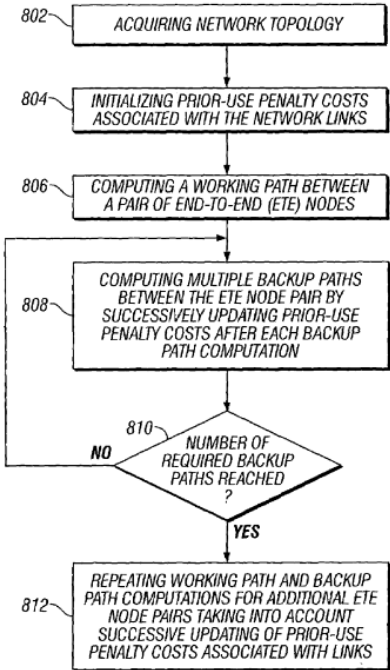
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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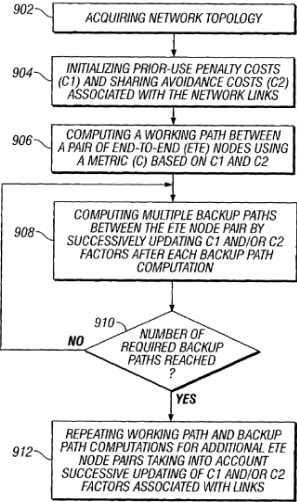
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4 <pre> graph TD 1002[MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> The flowchart, labeled FIG. 10, consists of four rectangular boxes arranged vertically and connected by downward-pointing arrows. The first box (1002) is labeled 'MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER'. The second box (1004) is labeled 'DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT'. The third box (1006) is labeled 'MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT'. The fourth box (1008) is labeled 'APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION'. FIG. 10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[1b] establishing the Bypass LSP for the Protected Primary LSP having a Point of Local Repair node and a Merge Point node;	Elie-Dit-Cosaque discloses establishing the Bypass LSP for the Protected Primary LSP having a Point of Local Repair node and a Merge Point node. <i>See, e.g.:</i> Accordingly, the present invention advantageously provides a system and method for implementing a shared protection scheme under a scenario of multiple failures in a network. In one aspect, the

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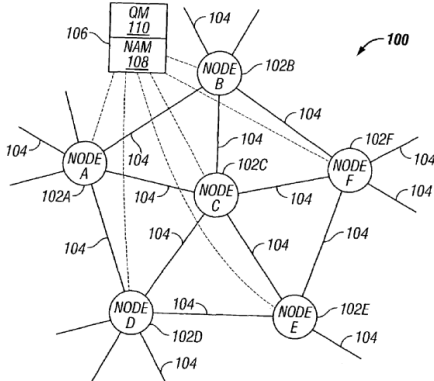
Claim	Disclosure
	present invention is directed to a method for providing protection in a communications network including a plurality of nodes coupled by communication links. The method commences by computing a working path between an ingress node and an egress node responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointness, as well as resource-based cost constraints in an exemplary implementation. Setup messages regarding the working path and the backup paths are then transmitted to the nodes spanning the paths. In one exemplary embodiment, the backup paths are computed using a methodology wherein the links between two backup paths or between a backup path and the working path are completely disjoint. In another exemplary embodiment, the backup and working paths may be partially disjoint in term of the links. In a further exemplary embodiment, both links as well as nodes may be completely or partially disjoint between the working path and backup paths. As a further variation, the backup path implementation may be activated based on network quality, wherein nodal and/or link quality degradation may be monitored for determining a failure condition arising out of temporal or spatial correlation of degradation events. 1:54–2:15  FIG. 1 Fig. 1 Referring now in particular to FIG. 1, depicted therein is an exemplary optical transport network 100 wherein a protection scheme involving multiple backup paths may be implemented in accordance with the teachings of the present invention. The optical transport network 100, which

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Claim	Disclosure
	may be implemented as a generalized multi-protocol label switched (GMPLS) optical transport network, includes a plurality of nodes or network elements 102A through 102F coupled by optical links 104. An optical link 104 is effectuated as a fiber carrying information between two nodes; for example, between Node A 102A and Node D 102D. The optical fiber is operable to carry information over a number of wavelengths or “channels”, effectuated by means of such well-known techniques as wavelength division multiplexing (WDM) or dense WDM (DWDM), wherein different channels of information are modulated using respective frequencies or wavelengths. The number of wavelengths, N, is dependent on implementation and may be different for each fiber. As the optical links 104 are unidirectional, typically a pair of links are disposed between any two adjacent nodes in order to facilitate bidirectional transport therebetween, each node receiving information on one link and transmitting information on the other link. It will be apparent that for purposes of illustration only one link is shown in FIG. 1, it being understood that at least one link in each direction would normally be used in an actual implementation. When information is received by an edge node (i.e., an ingress node) of the transport network 100, a path is computed between the ingress node and the destination node from which the information is to exit the transport network (i.e., the egress node). Thus, a path may be treated as a sequential concatenation of a number of links spanning between the ingress and egress nodes. By way of convention, a path may be designated as string of nodes disposed between the originating and destination nodes. For instance, the ordered sequence {A,D,C,F} designates a path between Node A as the ingress node and Node F as the egress node, Nodes D and C being intermediary nodes. 3:13–51 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12

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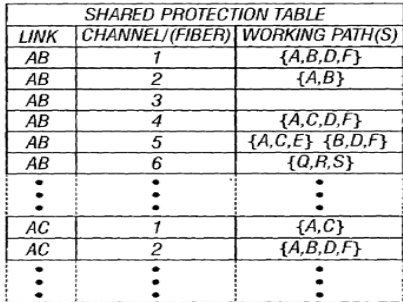
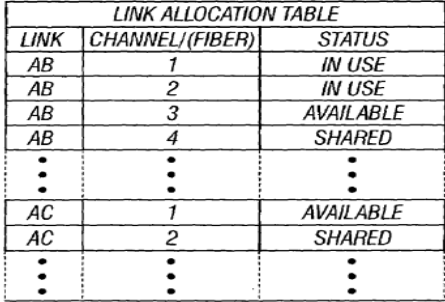
Claim	Disclosure
	 FIG. 3A  FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration,

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	for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 <pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10 FIG. 5A FIG. 5B FIG. 5C FIG. 5D FIG. 5E Figs. 5a–5e

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Claim	Disclosure
	FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A,

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Claim	Disclosure
	B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

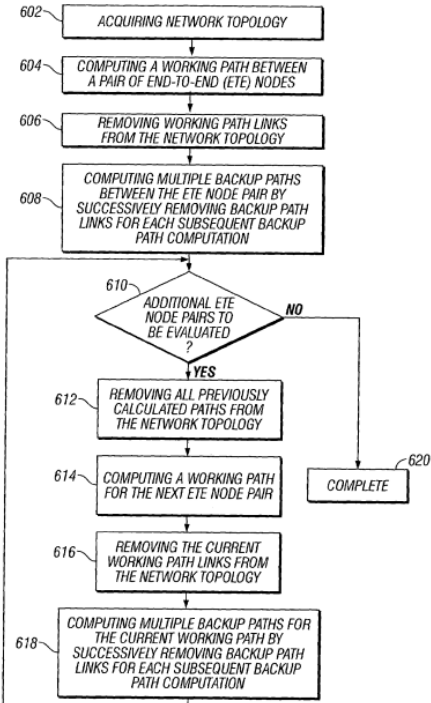
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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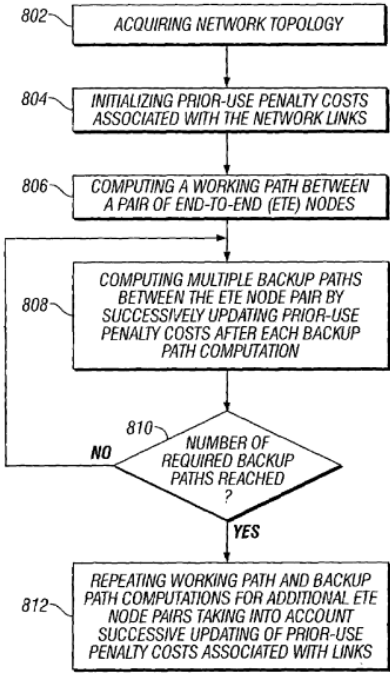
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END ETE NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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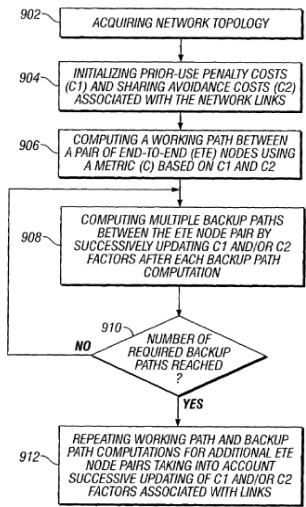
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

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Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4 <pre> graph TD 1002[1002 MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[1004 DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[1006 MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[1008 APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[1c] obtaining the nodes traversed by an end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node;	Elie-Dit-Cosaque discloses obtaining the nodes traversed by an end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node. <i>See, e.g.:</i> Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure																																																																		
	administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12 300A <table><tr><th colspan="3">SHARED PROTECTION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>WORKING PATH(S)</th></tr><tr><td>AB</td><td>1</td><td>{A,B,D,F}</td></tr><tr><td>AB</td><td>2</td><td>{A,B}</td></tr><tr><td>AB</td><td>3</td><td></td></tr><tr><td>AB</td><td>4</td><td>{A,C,D,F}</td></tr><tr><td>AB</td><td>5</td><td>{A,C,E} {B,D,F}</td></tr><tr><td>AB</td><td>6</td><td>{Q,R,S}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>{A,C}</td></tr><tr><td>AC</td><td>2</td><td>{A,B,D,F}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3A 300B <table><tr><th colspan="3">LINK ALLOCATION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>STATUS</th></tr><tr><td>AB</td><td>1</td><td>IN USE</td></tr><tr><td>AB</td><td>2</td><td>IN USE</td></tr><tr><td>AB</td><td>3</td><td>AVAILABLE</td></tr><tr><td>AB</td><td>4</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>AVAILABLE</td></tr><tr><td>AC</td><td>2</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could	SHARED PROTECTION TABLE			LINK	CHANNEL/(FIBER)	WORKING PATH(S)	AB	1	{A,B,D,F}	AB	2	{A,B}	AB	3		AB	4	{A,C,D,F}	AB	5	{A,C,E} {B,D,F}	AB	6	{Q,R,S}	⋮	⋮	⋮	AC	1	{A,C}	AC	2	{A,B,D,F}	⋮	⋮	⋮	LINK ALLOCATION TABLE			LINK	CHANNEL/(FIBER)	STATUS	AB	1	IN USE	AB	2	IN USE	AB	3	AVAILABLE	AB	4	SHARED	⋮	⋮	⋮	AC	1	AVAILABLE	AC	2	SHARED	⋮	⋮	⋮
SHARED PROTECTION TABLE																																																																			
LINK	CHANNEL/(FIBER)	WORKING PATH(S)																																																																	
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Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration, for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	<pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

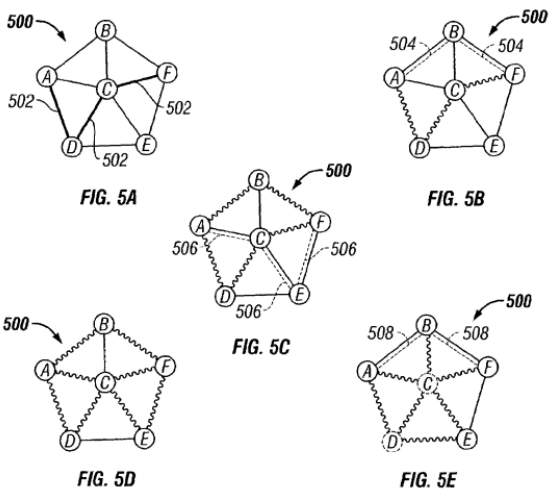
Claim	Disclosure
	 Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF.

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	Thereafter, if the requested connection session between nodes A and F warranted more than one backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

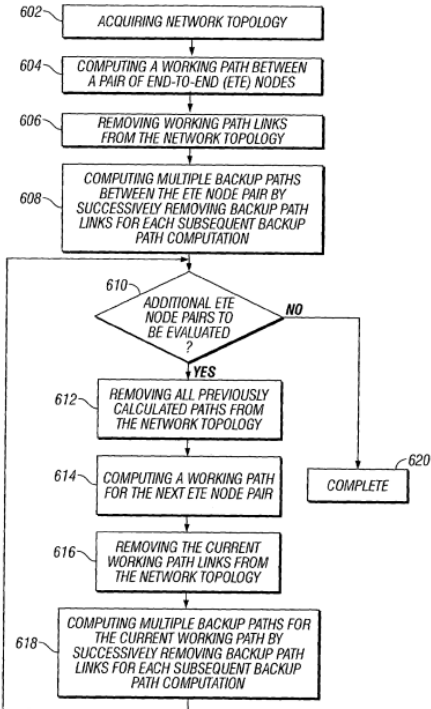
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

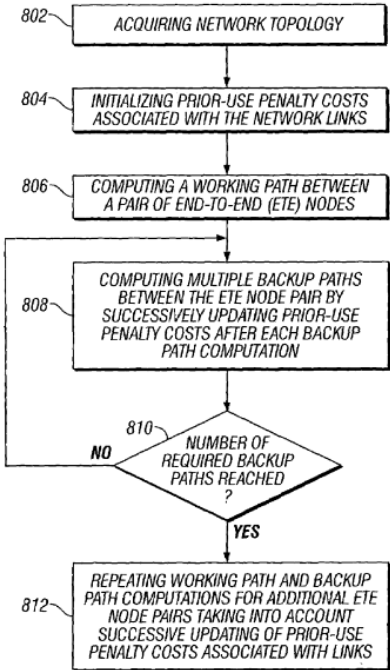
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED ?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

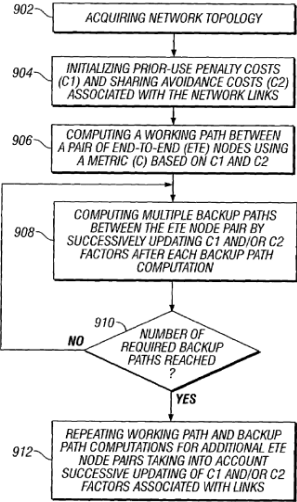
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

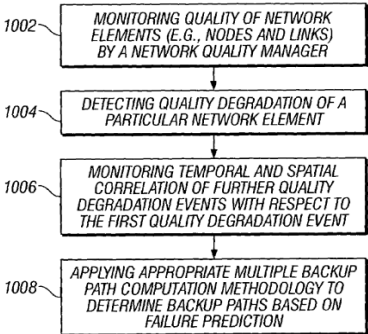
Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4  <pre> graph TD 1002[MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[1d] generating a request to a path calculator using the nodes traversed by said end-to-end path of said Bypass LSP for a disjoint path connecting said Point of Local Repair Node to said Merge Point node;	Elie-Dit-Cosaque discloses generating a request to a path calculator using the nodes traversed by said end-to-end path of said Bypass LSP for a disjoint path connecting said Point of Local Repair Node to said Merge Point node. <i>See, e.g.:</i> Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure																																																																		
	administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12 300A <table><tr><th colspan="3">SHARED PROTECTION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>WORKING PATH(S)</th></tr><tr><td>AB</td><td>1</td><td>{A,B,D,F}</td></tr><tr><td>AB</td><td>2</td><td>{A,B}</td></tr><tr><td>AB</td><td>3</td><td></td></tr><tr><td>AB</td><td>4</td><td>{A,C,D,F}</td></tr><tr><td>AB</td><td>5</td><td>{A,C,E} {B,D,F}</td></tr><tr><td>AB</td><td>6</td><td>{Q,R,S}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>{A,C}</td></tr><tr><td>AC</td><td>2</td><td>{A,B,D,F}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3A 300B <table><tr><th colspan="3">LINK ALLOCATION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>STATUS</th></tr><tr><td>AB</td><td>1</td><td>IN USE</td></tr><tr><td>AB</td><td>2</td><td>IN USE</td></tr><tr><td>AB</td><td>3</td><td>AVAILABLE</td></tr><tr><td>AB</td><td>4</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>AVAILABLE</td></tr><tr><td>AC</td><td>2</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could	SHARED PROTECTION TABLE			LINK	CHANNEL/(FIBER)	WORKING PATH(S)	AB	1	{A,B,D,F}	AB	2	{A,B}	AB	3		AB	4	{A,C,D,F}	AB	5	{A,C,E} {B,D,F}	AB	6	{Q,R,S}	⋮	⋮	⋮	AC	1	{A,C}	AC	2	{A,B,D,F}	⋮	⋮	⋮	LINK ALLOCATION TABLE			LINK	CHANNEL/(FIBER)	STATUS	AB	1	IN USE	AB	2	IN USE	AB	3	AVAILABLE	AB	4	SHARED	⋮	⋮	⋮	AC	1	AVAILABLE	AC	2	SHARED	⋮	⋮	⋮
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LINK	CHANNEL/(FIBER)	WORKING PATH(S)																																																																	
AB	1	{A,B,D,F}																																																																	
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Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration, for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	<pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

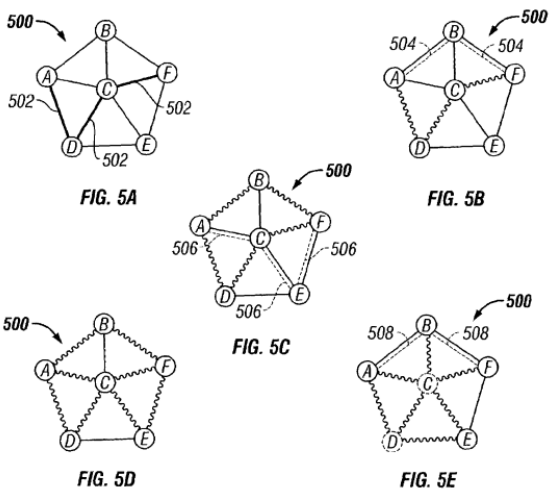
Claim	Disclosure
	 Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF.

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Claim	Disclosure
	Thereafter, if the requested connection session between nodes A and F warranted more than one backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

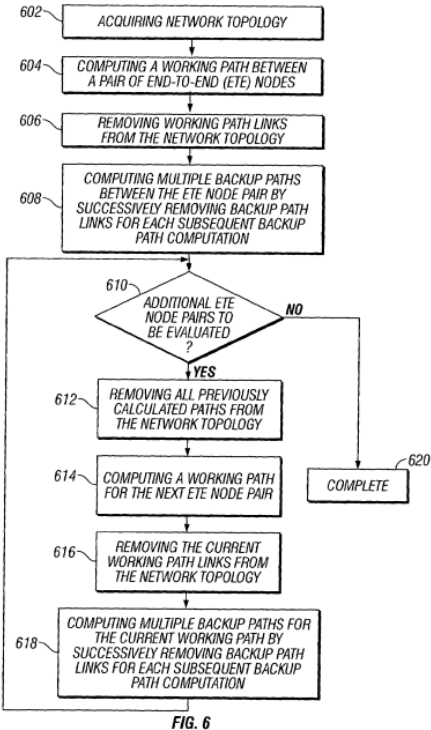
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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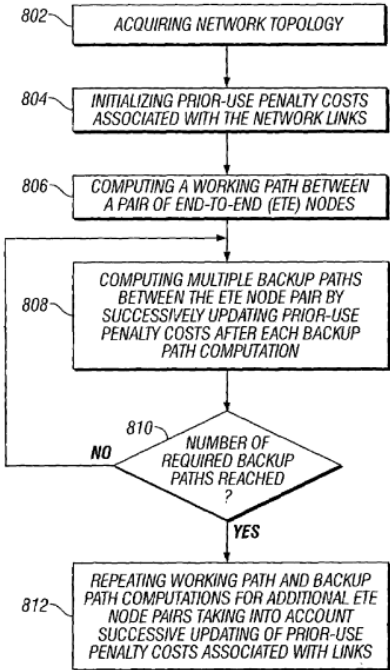
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

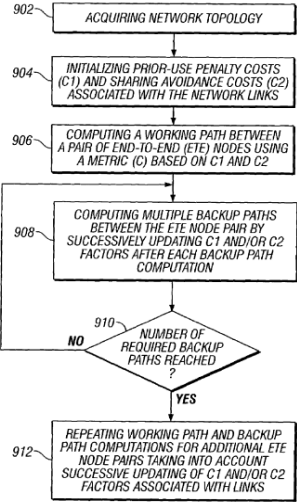
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS]</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

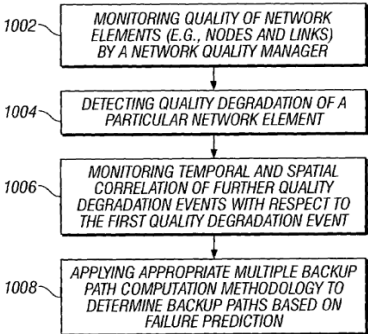
Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4  <pre> graph TD 1002[MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[1e] receiving a response from said path calculator; and	Elie-Dit-Cosaque discloses receiving a response from said path calculator. <i>See, e.g.:</i>

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	<pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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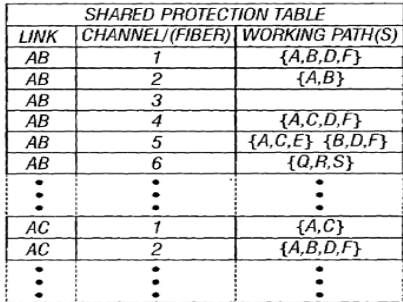
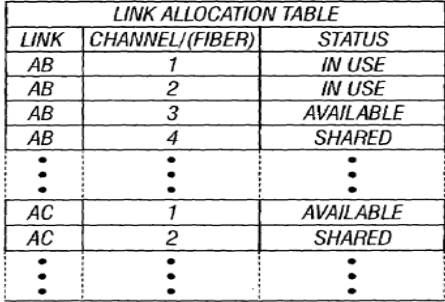
Claim	Disclosure
	 FIG. 3A  FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration,

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12

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Claim	Disclosure
	FIG. 5A FIG. 5B FIG. 5C FIG. 5D FIG. 5E Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one

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Claim	Disclosure
	backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

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Claim	Disclosure
	<pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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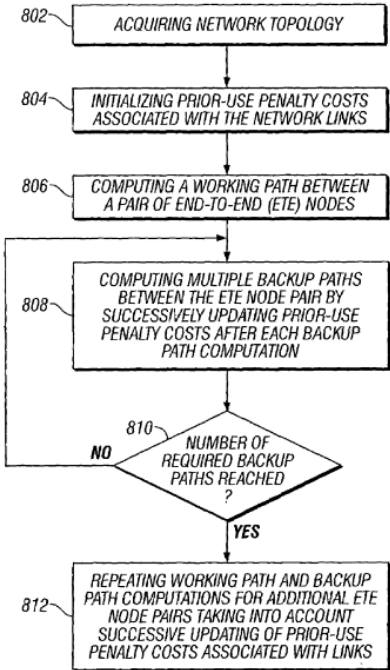
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED ?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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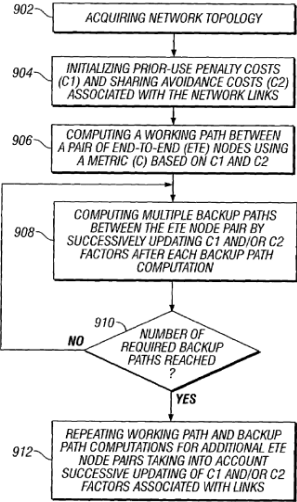
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS]</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

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Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4
[1f] in response to determining that a fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, signaling, to at least one other MPLS label switch router, said fully disjoint path as the Backup LSP to said Bypass LSP.	Elie-Dit-Cosaque discloses, in response to determining that a fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, signaling, to at least one other MPLS label switch router, said fully disjoint path as the Backup LSP to said Bypass LSP. <i>See, e.g.:</i> FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric

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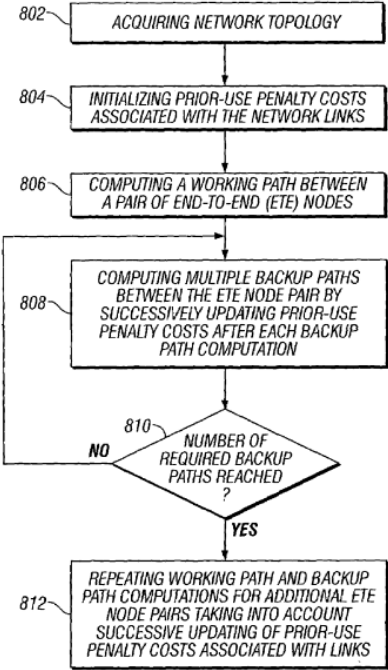
Claim	Disclosure
	(e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35 If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END ETE NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	<pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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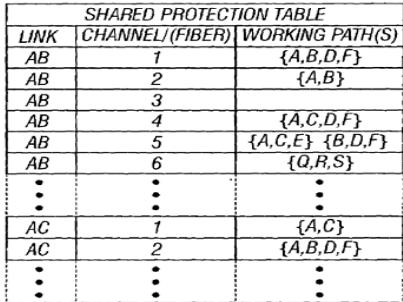
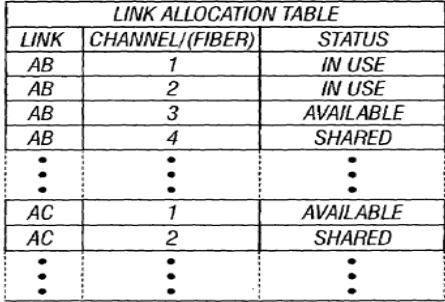
Claim	Disclosure
	 FIG. 3A  FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration,

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Claim	Disclosure
	for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12

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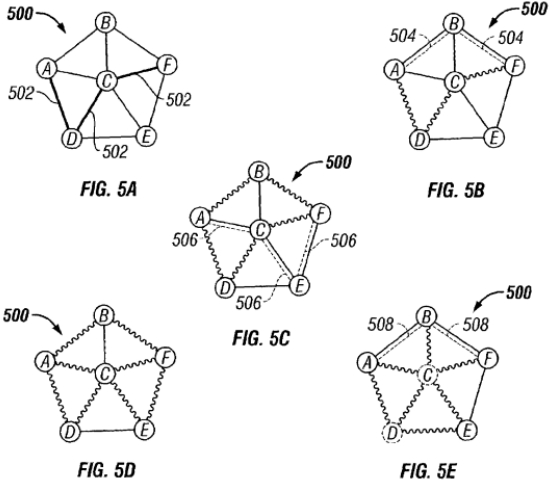
Claim	Disclosure
	 Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one

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	backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	<pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 <pre> graph TD 1002[1002 MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[1004 DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[1006 MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[1008 APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10

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	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[2] A method as claimed in claim 1, wherein said path calculator is a constraint based shortest path first calculator.	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses that said path calculator is a constraint based shortest path first calculator. <i>See, e.g.:</i>

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	In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 <pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the

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	network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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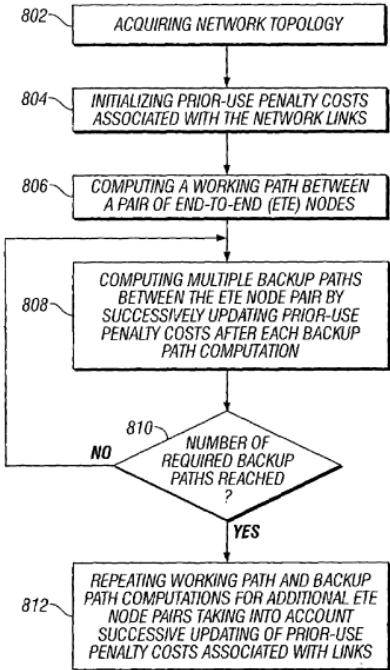
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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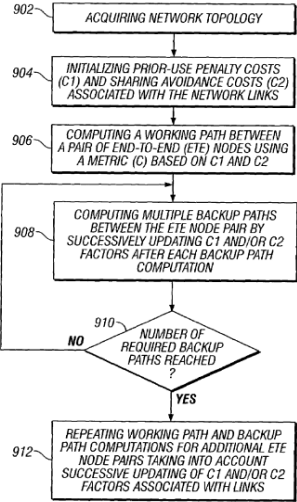
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

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	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4
[3a] A method as claimed in claim 1, wherein in response to determining that the fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available,	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses determining that the fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available. <i>See, e.g.:</i>

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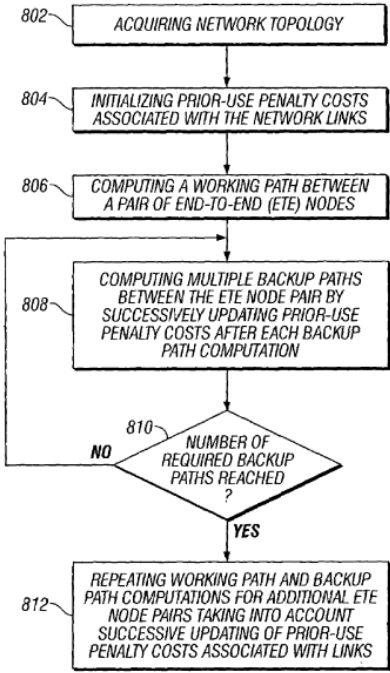
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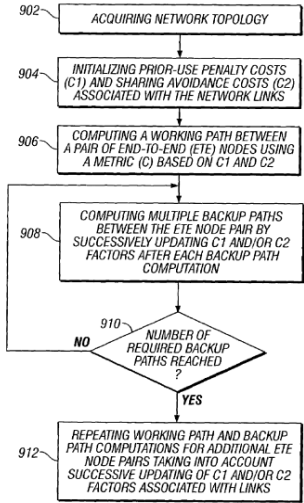
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[3b] in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, signaling, to at least one other MPLS label switch router, said partially disjoint path as the Backup LSP to said Bypass LSP.	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses, in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, signaling, to at least one other MPLS label switch router, said partially disjoint path as the Backup LSP to said Bypass LSP <i>See, e.g.:</i>

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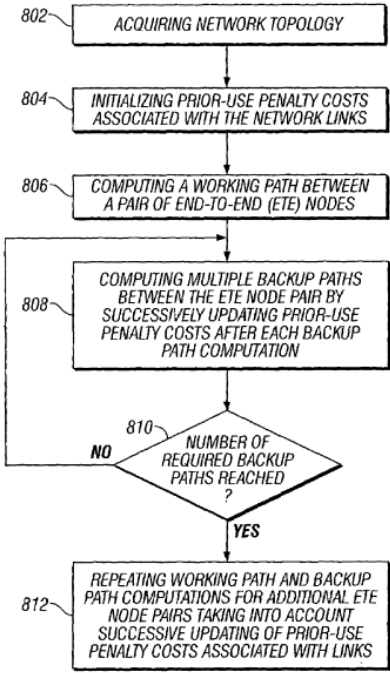
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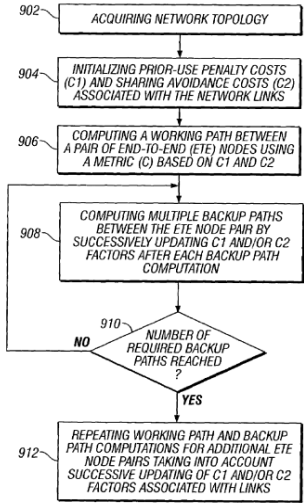
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[4a] A method as claimed in claim 3, wherein in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available, then	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available. <i>See, e.g.:</i> In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a

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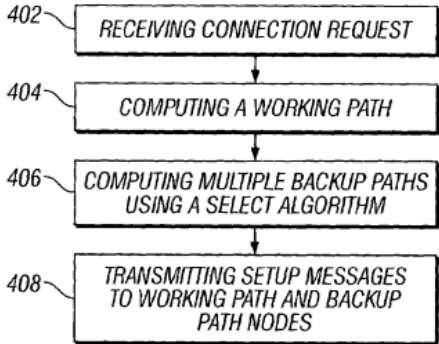
Claim	Disclosure
	Working Path field that identifies whether the working path needs a backup protection path. 5:28–44  <pre> graph TD 402[402 RECEIVING CONNECTION REQUEST] --> 404[404 COMPUTING A WORKING PATH] 404 --> 406[406 COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[408 TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

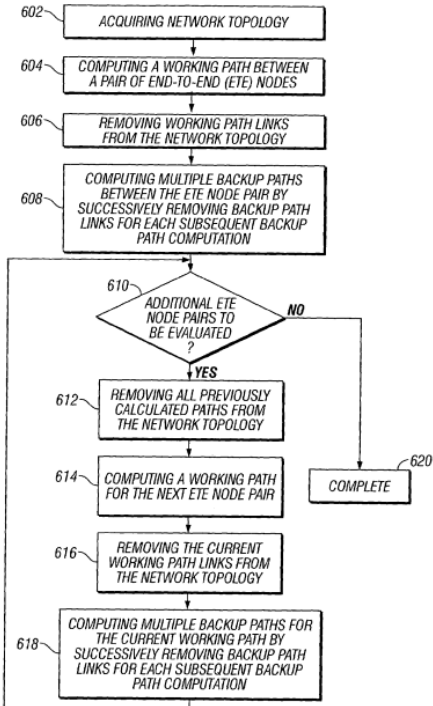
Claim	Disclosure
	messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10  <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the

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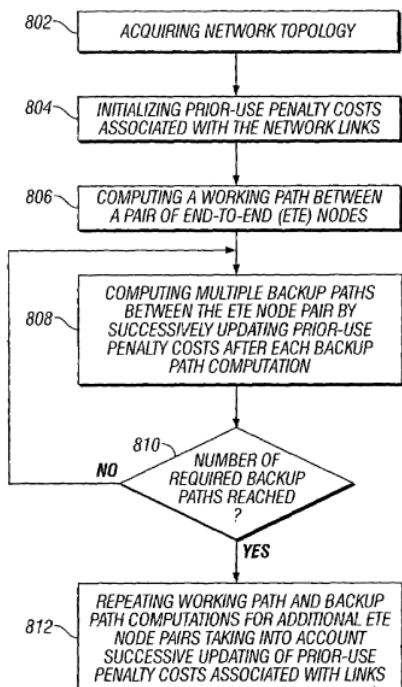
Claim	Disclosure
	network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35 If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31 <pre> graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] 912 --> 906 </pre> FIG. 9

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Claim	Disclosure
	Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4
[4b] signaling an error on the attempt to provide a Backup LSP.	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses, in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available, signaling an error on the attempt to provide a Backup LSP. <i>See, e.g.:</i>

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	In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44 <pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the

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Claim	Disclosure
	network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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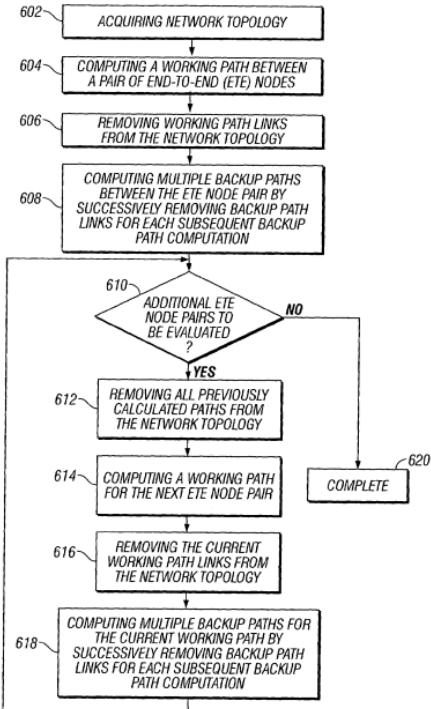
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

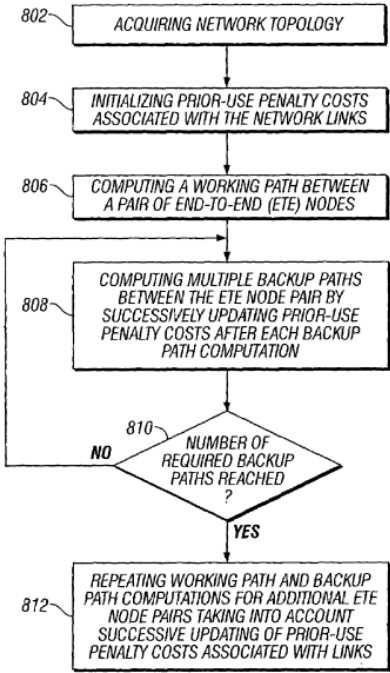
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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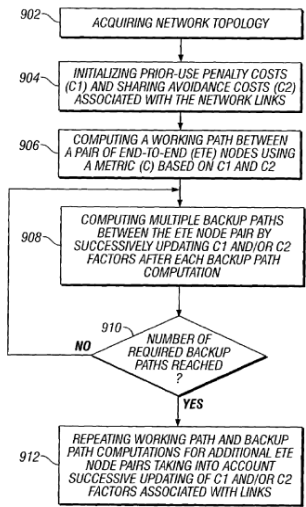
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4
[5a] A method as claimed in claim 1 after said obtaining step, comprising further steps of: procuring a Shared Risk Link Groups (SRLG) associated with the nodes traversed by the end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node; and	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses procuring a Shared Risk Link Groups (SRLG) associated with the nodes traversed by the end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node. <i>See, e.g.:</i>

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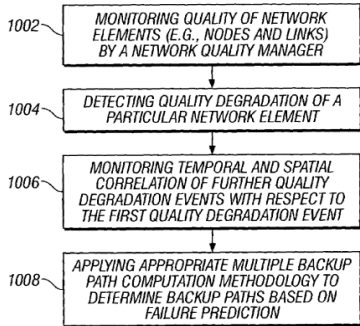
Claim	Disclosure
	 <pre> graph TD 1002[1002 MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[1004 DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[1006 MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[1008 APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10 As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation

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Claim	Disclosure
	profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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Claim	Disclosure
	Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

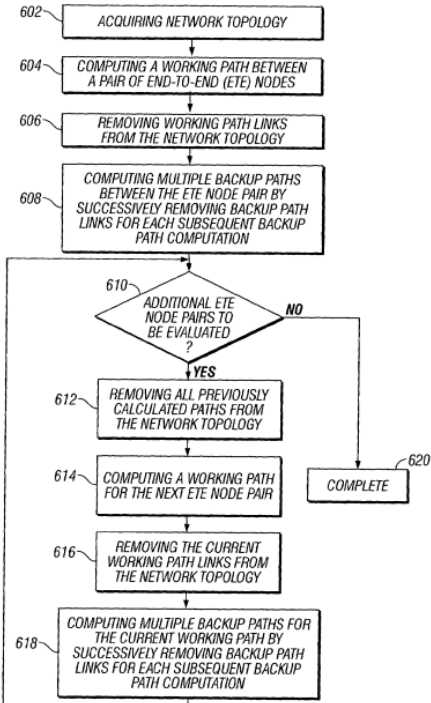
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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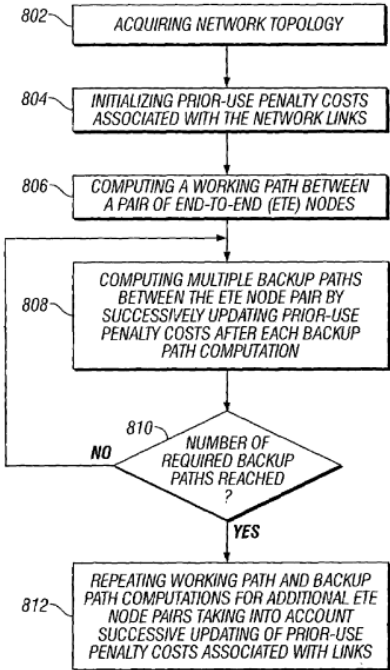
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED ?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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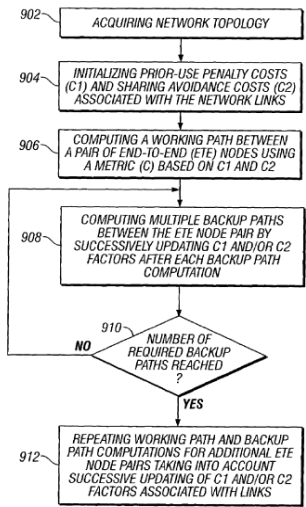
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

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	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4
[5b] providing said Shared Risk Link Groups as part of said generating a request step to said calculator for use in calculating said disjoint path.	<i>See claim 1 supra.</i> Elie-Dit-Cosaque discloses providing said Shared Risk Link Groups as part of said generating a request step to said calculator for use in calculating said disjoint path. <i>See, e.g.:</i>

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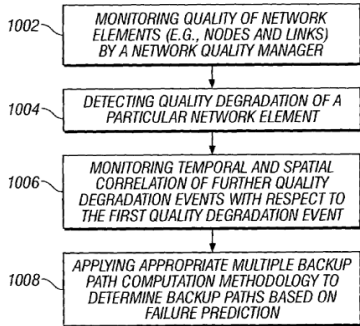
Claim	Disclosure
	 <pre> graph TD 1002[1002 MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[1004 DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[1006 MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[1008 APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10 As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation

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	profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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	FIG. 5A FIG. 5B FIG. 5C FIG. 5D FIG. 5E Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF. Thereafter, if the requested connection session between nodes A and F warranted more than one

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	backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

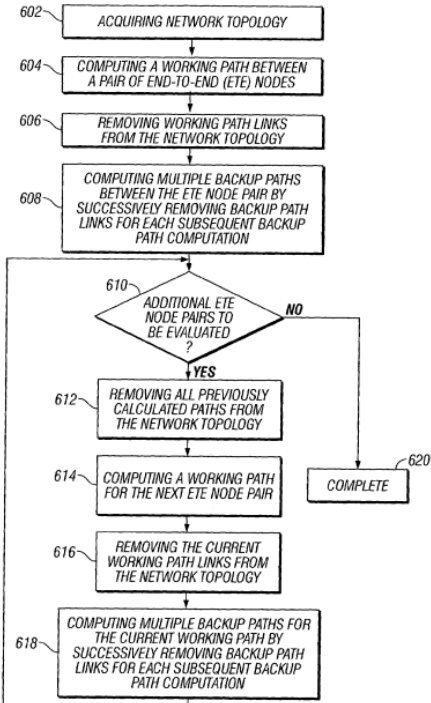
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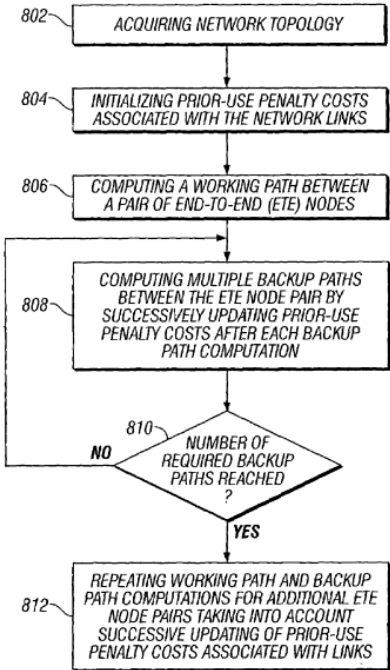
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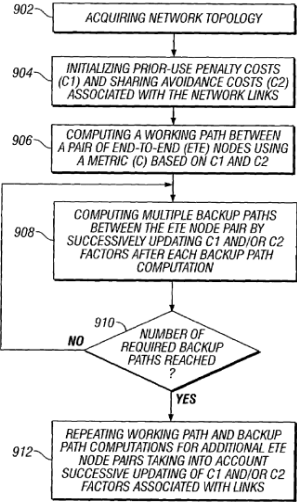
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[6pre] A non-transitory machine readable storage medium encoded with instructions for execution by a network processor of a Multiprotocol Label Switching (MPLS) label switch for providing a Backup Label Switched Path (LSP) to a Bypass LSP already established for a Protected	To the extent the preamble is limiting, Elie-Dit-Cosaque discloses a non-transitory machine readable storage medium encoded with instructions for execution by a network processor of a Multiprotocol Label Switching (MPLS) label switch for providing a Backup Label Switched Path (LSP) to a Bypass LSP already established for a Protected Primary LSP. <i>See, e.g.:</i>

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Primary LSP, the medium comprising:	FIG. 2 Fig. 2 FIG. 2 depicts a block diagram of an embodiment of an exemplary optical network node 200. A routing part 202 including routing protocol logic 204, a global data base 206 and control logic 208, is coupled to an optical cross-connect (OXC) module 210 which includes a switching matrix 212 disposed between one or more input demultiplexers (DEMUXes) and one or more output DEMUXes. In general operation, router 202 is responsible for control signaling in the network in which the node 200 is disposed, e.g., the optical transport network 100 shown in FIG. 1, using appropriate routing logic 204. The global database 206 comprises one or more tables that provide a current topology of the network 100 for intelligent, dynamic creation of network paths under control of control logic 208. Preferably, in one implementation, the global database 206 provides information regarding each channel of each link in the entire network domain. Status of each channel can be one of the following: (i) channel is used in a working path; (ii) channel is used in a protection or backup path, but not available for sharing; (iii) channel is used in a backup path and is available for sharing; and (iv) channel is not used for either working or protection paths. Further, where the NAM/QM functionality is distributed over network nodes, the global database may also

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	include quality information relating to the network components. distributed over network nodes, the global database may also include quality information relating to the network components. The OXC module 210 is responsible for passing information from a channel on an incoming fiber to a channel on an outgoing fiber using the switching matrix 212. By way of example, two incoming fibers 214A and 214D and two outgoing fibers 214B and 214C are shown. Reference numerals 216A and 216D refer to a pair of DEMUXes operable to separate the incoming channels 218 and 222 ($\lambda 1$ through λN) associated with the incoming fiber 214A and 214D, respectively, before being passed to the switching matrix 212. The switching matrix 212 passes each incoming channel to an outgoing channel 220 as may be defined by a local database 228. A pair of MUXes 216B and 214C operate to multiplex the outgoing channels 220 and 224 for transmission onto fibers 214B and 214C respectively. Whereas the same number of wavelengths (i.e., optical channels $\lambda 1$ through λN) are shown for both incoming and outgoing links, different implementations are possible. Further, a regenerator module 226 may be used for coupling channels with different wavelengths. Protection scheme for a communications network under multiple failures. Title. A system and method for implementing a shared protection scheme under a scenario of multiple failures in an optical network. In one embodiment of the invention, a working path between an ingress node and an egress node is computed responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointedness, as well as resource-based cost constraints. Abstract. A network operator typically takes into consideration multiple objectives when routing traffic through a network. One objective may be to minimize cost. Another objective may be to minimize transmission impairments. A third objective may be to maximize the possibility that the network can be restored using a backup path in the event of a failure thereof. Generally, there are three types of restoration schemes: dedicated restoration, shared restoration, and best effort restoration. In dedicated restoration, the capacity of a protection, or restoration, path is reserved for an individual demand. In shared restoration, the restoration capacity is reserved, but shared across multiple demands. In best effort restoration, no reservation is made and restoration capacity is allocated in real time on an as-available basis. The first two classes of restoration both

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	have guaranteed restoration in the event of a single failure; however, they differ in restoration time, as shared restoration requires real-time path setup. Whereas intelligent mesh routing techniques have been available for computing a backup path in a 1:N or M:N shared restoration scheme, such techniques tend to be inadequate where multiple failures are encountered in a network. Further, known protection path implementations do not address the issue of correlated multiple failures, especially in the context of applicable network resource constraints. 1:25–50 Accordingly, the present invention advantageously provides a system and method for implementing a shared protection scheme under a scenario of multiple failures in a network. In one aspect, the present invention is directed to a method for providing protection in a communications network including a plurality of nodes coupled by communication links. The method commences by computing a working path between an ingress node and an egress node responsive to a connection request received in the network. One or more backup paths are computed between the ingress and egress nodes, which are activatable upon a failure condition associated with the working path or the backup paths. The backup paths may be based on link and/or node disjointedness, as well as resource-based cost constraints in an exemplary implementation. Setup messages regarding the working path and the backup paths are then transmitted to the nodes spanning the paths. In one exemplary embodiment, the backup paths are computed using a methodology wherein the links between two backup paths or between a backup path and the working path are completely disjointed. In another exemplary embodiment, the backup and working paths may be partially disjoint in term of the links. In a further exemplary embodiment, both links as well as nodes may be completely or partially disjoint between the working path and backup paths. As a further variation, the backup path implementation may be activated based on network quality, wherein nodal and/or link quality degradation may be monitored for determining a failure condition arising out of temporal or spatial correlation of degradation events. 1:54–2:15

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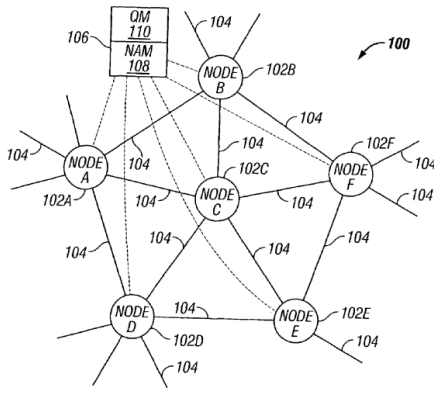
Claim	Disclosure
	 FIG. 1 Fig. 1 Referring now in particular to FIG. 1, depicted therein is an exemplary optical transport network 100 wherein a protection scheme involving multiple backup paths may be implemented in accordance with the teachings of the present invention. The optical transport network 100, which may be implemented as a generalized multi-protocol label switched (GMPLS) optical transport network, includes a plurality of nodes or network elements 102A through 102F coupled by optical links 104. An optical link 104 is effectuated as a fiber carrying information between two nodes; for example, between Node A 102A and Node D 102D. The optical fiber is operable to carry information over a number of wavelengths or “channels”, effectuated by means of such well-known techniques as wavelength division multiplexing (WDM) or dense WDM (DWDM), wherein different channels of information are modulated using respective frequencies or wavelengths. The number of wavelengths, N, is dependent on implementation and may be different for each fiber. As the optical links 104 are unidirectional, typically a pair of links are disposed between any two adjacent nodes in order to facilitate bidirectional transport therebetween, each node receiving information on one link and transmitting information on the other link. It will be apparent that for purposes of illustration only one link is shown in FIG. 1, it being understood that at least one link in each direction would normally be used in an actual implementation. When information is received by an edge node (i.e., an ingress node) of the transport network 100, a path is computed between the ingress node and the destination node from which the information is to exit the transport network (i.e., the egress node). Thus, a path may be treated as a sequential concatenation of a number of links spanning between the ingress and egress nodes. By way of convention, a path may

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	be designated as string of nodes disposed between the originating and destination nodes. For instance, the ordered sequence {A,D,C,F} designates a path between Node A as the ingress node and Node F as the egress node, Nodes D and C being intermediary nodes. 3:13–51 Several techniques are available for computing end-to-end (ETE) paths in the optical transport network 100 based on a variety of criteria, e.g., hop count, link costs, et cetera. A network administrator and manager (NAM) 108 may be disposed centrally or distributed over one or more nodes of the transport network 100. A quality monitor (QM) 110 provided with the NAM functionality 108 is operable to monitor the various network components, e.g., nodes and links, and apply suitable criteria to determine if a node or link will experience degradation (i.e., a failure). In one implementation, the NAM/QM functionality may be co-located as an administrative node 106 on the network operable to monitor the various network components, i.e., nodes and links, and take appropriate actions with respect to path selection, switching, and restoration. As will be seen in detail hereinbelow, the NAM/QM integrated functionality is also capable of ascertaining spatial and temporal correlations among multiple failures that may afflict the network and accordingly effectuate one or more protective backup paths using the methodologies of the present invention. 3:60–4:12 300A <table><tr><th colspan="3">SHARED PROTECTION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>WORKING PATH(S)</th></tr><tr><td>AB</td><td>1</td><td>{A,B,D,F}</td></tr><tr><td>AB</td><td>2</td><td>{A,B}</td></tr><tr><td>AB</td><td>3</td><td></td></tr><tr><td>AB</td><td>4</td><td>{A,C,D,F}</td></tr><tr><td>AB</td><td>5</td><td>{A,C,E} {B,D,F}</td></tr><tr><td>AB</td><td>6</td><td>{Q,R,S}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>{A,C}</td></tr><tr><td>AC</td><td>2</td><td>{A,B,D,F}</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3A 300B <table><tr><th colspan="3">LINK ALLOCATION TABLE</th></tr><tr><th>LINK</th><th>CHANNEL/(FIBER)</th><th>STATUS</th></tr><tr><td>AB</td><td>1</td><td>IN USE</td></tr><tr><td>AB</td><td>2</td><td>IN USE</td></tr><tr><td>AB</td><td>3</td><td>AVAILABLE</td></tr><tr><td>AB</td><td>4</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr><tr><td>AC</td><td>1</td><td>AVAILABLE</td></tr><tr><td>AC</td><td>2</td><td>SHARED</td></tr><tr><td>⋮</td><td>⋮</td><td>⋮</td></tr></table> FIG. 3B Figs. 3a, 3b Continuing to refer to FIG. 2, global database 206 includes information for determining the existence of links having channels currently used for protection paths, where the channels can be shared with other protection paths, and links having channels that are currently unused by either	SHARED PROTECTION TABLE			LINK	CHANNEL/(FIBER)	WORKING PATH(S)	AB	1	{A,B,D,F}	AB	2	{A,B}	AB	3		AB	4	{A,C,D,F}	AB	5	{A,C,E} {B,D,F}	AB	6	{Q,R,S}	⋮	⋮	⋮	AC	1	{A,C}	AC	2	{A,B,D,F}	⋮	⋮	⋮	LINK ALLOCATION TABLE			LINK	CHANNEL/(FIBER)	STATUS	AB	1	IN USE	AB	2	IN USE	AB	3	AVAILABLE	AB	4	SHARED	⋮	⋮	⋮	AC	1	AVAILABLE	AC	2	SHARED	⋮	⋮	⋮
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	working paths or protection paths. Whereas it should be apparent that the global database 206 may be implemented in a variety of forms, FIGS. 3A and 3B depict two exemplary database portions for effectuating multiple backup paths in accordance with one embodiment of the present invention. As shown in FIG. 3A, a global shared protection table 300A contains entries for each channel in each link that is used for path protection. In the illustrated embodiment, each channel is identified by the link and channel number fields. If there are multiple fibers between two nodes, each channel could be identified by link, fiber, and channel number within the fiber. The working path(s) associated with the channel are identified in the appropriate Working Path field which is set forth as a {NODES} field that lists all nodes on that Working Path. 4:59–5:11 A global link allocation table 300B is shown in FIG. 3B, which maintains a record of the status of all channels for all links in the network domain. Again, each channel on each of the links is identified by link and channel number (and, optionally, fiber number) fields. A Status field identifies the channel as being “Shared”, “In Use” or “Available”. “Shared” status is employed when a channel is currently used in a path, e.g., for a protection path, that could be used for shared protection. “In Use” identifies channels used for working paths. Further, “In Use” status may also be applied for protection paths for which shared protection is not to be used. By way of illustration, for a high quality class of service, a working path may not be used using 1+1 protection, where sharing of the protect channels is not allowed. Finally, “Available” identifies channels that not currently used for protection or working paths. 5:12–27 In operation, every exemplary network node 200 maintains the entries in the global allocation database for its own links. Information regarding other links in the global allocation database may be compiled from allocation information provided by other nodes in the network domain. In one implementation, such information may be shared among all nodes in the network using a variant of the Open Shortest Path First (OSPF) protocol upgraded for optical networks. Further, protection messages for updating the nodal global allocation database may be transmitted using the Label Distribution Protocol (LDP) messages. By way of example, the protection messages may be the same as those used for reservation of a working path, with the addition of two fields: (1) a Type field that indicates whether the connection is for a protection path or a working path; and (2) a Working Path field that identifies whether the working path needs a backup protection path. 5:28–44

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	<pre> graph TD 402[RECEIVING CONNECTION REQUEST] --> 404[COMPUTING A WORKING PATH] 404 --> 406[COMPUTING MULTIPLE BACKUP PATHS USING A SELECT ALGORITHM] 406 --> 408[TRANSMITTING SETUP MESSAGES TO WORKING PATH AND BACKUP PATH NODES] </pre> FIG. 4 Fig. 4 In a presently preferred exemplary embodiment of the present invention, the protection path selection is performed at the source node (i.e., ingress node), as is the working path selection. FIG. 4 is a flow chart of an embodiment of a method of the present invention for implementing a protection scheme capable of withstanding multiple failures. When a connection request is received at an ingress node (step 402) which has a computer readable medium having instructions therein which when executed by a computer cause the ingress node to compute a working path based on the network topology acquired from the co-located global database or from a centralized administrative node (step 404). The working path may be calculated using a number of various well-known techniques. An exemplary embodiment is provided in the following co-pending commonly-owned U.S. patent application entitled “Informed Dynamic Path Protection For Optical Networks,” filed Nov. 29, 2001, application Ser. No. 09/998,362, cross-referenced hereinabove and incorporated by herein. Thereafter, one or more backup paths are computed using one of several methodologies set forth in detail below for purposes of providing protection against multiple failures (step 406). As will be seen, these methodologies vary depending upon link disjointedness, node disjointedness, and cost factors associated with spatial/temporal correlations among failures. Once the working path and multiple backup path computations are completed, appropriate setup and/or activation messages may be transmitted from the source node to the path nodes of the network (step 408). Again, additional details concerning message transmission and wavelength assignment process may be found in the cross-referenced U.S. patent application identified above. 5:45–6:10

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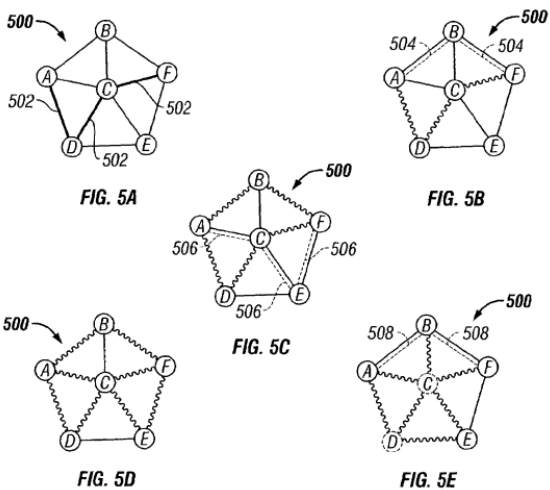
Claim	Disclosure
	 Figs. 5a–5e FIGS. 5A-5E illustrate different topological stages of an exemplary network 500 wherein multiple backup paths may be computed in accordance with the teachings of the present invention depending on link disjointedness and/or node disjointedness. Network 500 comprises five nodes, A through F, wherein an exemplary working path from Node A to Node F is identified as Path {A,D,C,F}, denoted by reference numeral 502. In a complete link disjoint scheme, successive path computations involve network topologies wherein the links that make up previously computed paths are logically removed from the topology. On the other hand, in partial link disjoint scheme, there may be some link commonality between a new path and a previously computed path, the degree of commonality depending upon certain cost/penalty constraints associated with sharing or non-sharing of protection links. FIGS. 5B through 5D depict three topologies that obtain with respect to the exemplary network 500 when a complete link disjoint scheme is used for calculating multiple backup paths. In these FIGURES, previously computed paths are illustrated as having links with wavy lines, which are logically removed from the network topology for calculating subsequent paths. After removing the exemplary working path 502 from the network topology (i.e., links AD, DC and CF are shown in wavy lines), a first protection path is computed using any known algorithm. For purposes of illustration, a protection path 504 is shown in a dashed line between the source node (Node A) and the destination node (Node F), using links AB and BF.

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	Thereafter, if the requested connection session between nodes A and F warranted more than one backup, another iteration of a protection path computation takes place. As shown in FIG. 5C, links AB and BF are also removed from the network topology for this calculation (i.e., AB and BF links are shown in wavy lines). A second protection path between Node A and Node F is computed, again using any known or heretofore unknown algorithm, after removing all previously calculated links from the topological graph. Reference numeral 506 refers to the exemplary second protection path comprising links AC and CF. Upon removal of these newly calculated links, the network graph results in a topology that will not permit any further paths between the source and destination nodes (FIG. 5D). 6:11–52 FIG. 5E depicts the exemplary network topology in a complete node disjoint scenario. As can be readily appreciated, the network topology graph shrinks even more rapidly in this scenario due to the fact that when a previously used node (either in a working path or in a backup path) is logically removed from the graph, all links associated with that node are also removed. Clearly, the end nodes, i.e., the source and destination nodes, are not deleted from the subsequent path calculations. Accordingly, upon removal of the intermediary nodes C and D (as illustrated by the dashed circles around them) from the graph, all links associated therewith are also removed, leaving only nodes A, B, E and F. Again, a protection path may be calculated within the resulting graph using any technique, e.g., Dijkstra's Shortest Path First (SPF) algorithm. Reference numeral 508 refers to an exemplary backup path involving links AB and BF, as illustrated by the dashed line segments. 6:53–7:2 It should be appreciated that a diverse set of backup paths can provide better protection against multiple failure events in the network. For instance, in the example of a working path being protected by two backup paths, the probability of failure is intuitively low, as even after the failure of the working path and one of the protection paths it is still possible to restore the connection between the end nodes. A single backup path may also provide protection against multiple failures as long as the failures do not affect the working and protection paths simultaneously. Accordingly, having multiple backup paths advantageously decreases the probability of simultaneous interruption of all backups. Moreover, the overall benefits of multiple backup paths are clearly related to spatial and temporal distributions of the failures as well as the selected methodology for computing backup paths. 7:3–18

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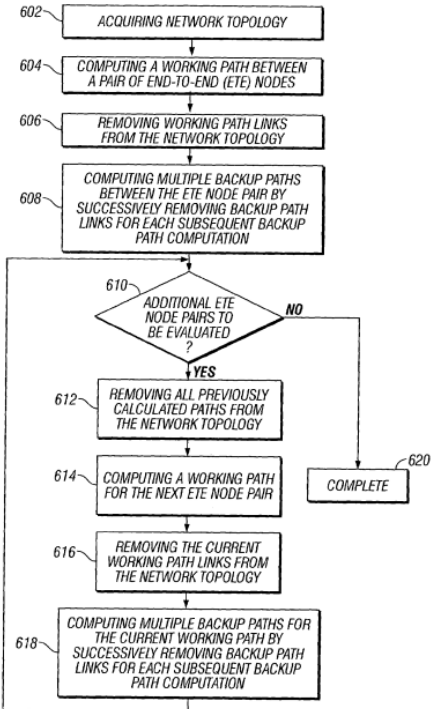
Claim	Disclosure
	 <pre> graph TD 602[602 ACQUIRING NETWORK TOPOLOGY] --> 604[604 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 604 --> 606[606 REMOVING WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 606 --> 608[608 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 608 --> 610{610 ADDITIONAL ETE NODE PAIRS TO BE EVALUATED?} 610 -- NO --> 620[620 COMPLETE] 610 -- YES --> 612[612 REMOVING ALL PREVIOUSLY CALCULATED PATHS FROM THE NETWORK TOPOLOGY] 612 --> 614[614 COMPUTING A WORKING PATH FOR THE NEXT ETE NODE PAIR] 614 --> 616[616 REMOVING THE CURRENT WORKING PATH LINKS FROM THE NETWORK TOPOLOGY] 616 --> 618[618 COMPUTING MULTIPLE BACKUP PATHS FOR THE CURRENT WORKING PATH BY SUCCESSIVELY REMOVING BACKUP PATH LINKS FOR EACH SUBSEQUENT BACKUP PATH COMPUTATION] 618 --> 610 </pre> FIG. 6 Fig. 6 FIG. 6 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are completely disjoint. First, a network topology is acquired (step 602), wherein all links in the network topology may be attributed the same cost. Thereafter, a working path is computed pursuant to a connection request between a pair of end-to-end (ETE) nodes, i.e., the source and destination nodes (step 604). As noted in the foregoing discussion, any known or heretofore unknown routing technique may be employed that optimizes a suitable metric (e.g., hop count, path distance, et cetera). Working path links are then logically removed from the network topology (step 606) so as to ensure that they are not reused for subsequent paths. One or more backup paths between the ETE nodes may then be calculated in a similar fashion until the requisite number of paths are computed or the resultant topology does not sustain any more backups (step 608). 7:19–35

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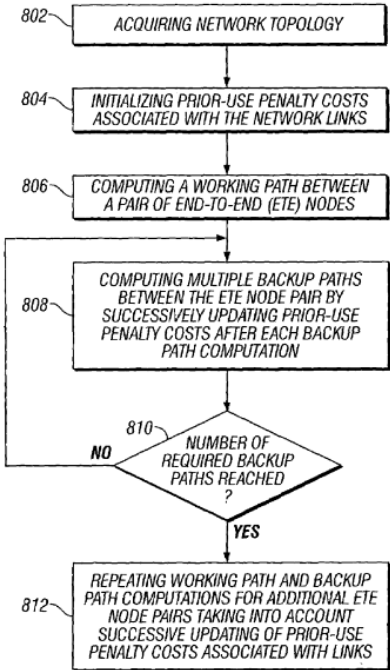
Claim	Disclosure
	If no additional ETE pairs are to be evaluated as well (decision block 610), the process flow then stops (step 620). Otherwise, operations similar to those described above are carried out (steps 612, 614, 616 and 618) to compute multiple backup paths that are completely link disjoint. The process flow may continue until no more ETE pairs are left. 7:36–41  <pre> graph TD 802[802 ACQUIRING NETWORK TOPOLOGY] --> 804[804 INITIALIZING PRIOR-USE PENALTY COSTS ASSOCIATED WITH THE NETWORK LINKS] 804 --> 806[806 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES] 806 --> 808[808 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING PRIOR-USE PENALTY COSTS AFTER EACH BACKUP PATH COMPUTATION] 808 --> 810{810 NUMBER OF REQUIRED BACKUP PATHS REACHED ?} 810 -- NO --> 808 810 -- YES --> 812[812 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF PRIOR-USE PENALTY COSTS ASSOCIATED WITH LINKS] </pre> FIG. 8 Fig. 8 Because of resource constraints and connectivity blocking in a network, it may not be feasible to treat the links, nodes, or both, in a completely disjointed fashion for calculating the backup paths. A variable cost factor may be employed to penalize the links and/or nodes already used for a connection. FIG. 8 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links are partially disjoint. Upon obtaining the network

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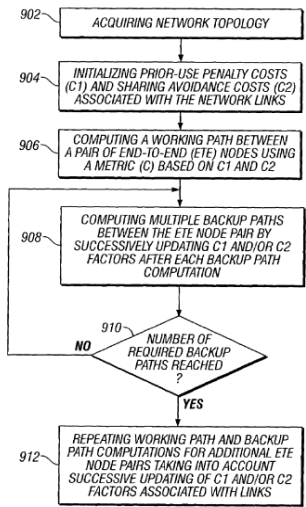
Claim	Disclosure
	topology (step 802), prior-use penalty costs (C1) associated with the network links may be initialized (step 804). A working path is then computed for the ingress and egress node pair associated with the connection request (step 806). Subsequent multiple backup paths are computed thereafter by successively updating the link penalty costs after each backup path calculation (step 808). As a result, the methodology attempts to avoid the links that have already been used in a working path connection or a backup connection. The backup paths, therefore, are the destination paths calculated with the new metric that is cost-aware for each iterative step. These steps may be repeated until the number of backup paths requested is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 810). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link penalty costs are properly taken into account for each pair and each path computation (step 812). 8:4–31  <pre>graph TD 902[902 ACQUIRING NETWORK TOPOLOGY] --> 904[904 INITIALIZING PRIOR-USE PENALTY COSTS (C1) AND SHARING AVOIDANCE COSTS (C2) ASSOCIATED WITH THE NETWORK LINKS] 904 --> 906[906 COMPUTING A WORKING PATH BETWEEN A PAIR OF END-TO-END (ETE) NODES USING A METRIC (C) BASED ON C1 AND C2] 906 --> 908[908 COMPUTING MULTIPLE BACKUP PATHS BETWEEN THE ETE NODE PAIR BY SUCCESSIVELY UPDATING C1 AND/OR C2 FACTORS AFTER EACH BACKUP PATH COMPUTATION] 908 --> 910{910 NUMBER OF REQUIRED BACKUP PATHS REACHED?} 910 -- NO --> 908 910 -- YES --> 912[912 REPEATING WORKING PATH AND BACKUP PATH COMPUTATIONS FOR ADDITIONAL ETE NODE PAIRS TAKING INTO ACCOUNT SUCCESSIVE UPDATING OF C1 AND/OR C2 FACTORS ASSOCIATED WITH LINKS] style 910 fill:#fff,stroke:#000,stroke-width:1px style 912 fill:#fff,stroke:#000,stroke-width:1px</pre> FIG. 9 Fig. 9 As a further variation, both links as well as nodes may be treated as partially disjoint. Again, it should be noted that whereas the partial-disjoint approach may provide a more dynamic and diverse protection scheme for a given topology (although the working and backup paths may not be disjoint

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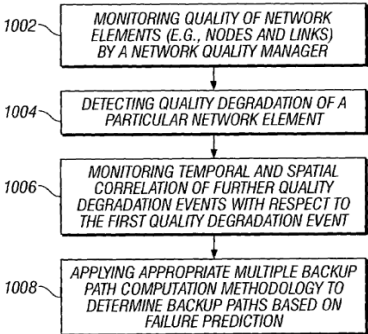
Claim	Disclosure
	end-to-end), network resources may be constrained enough that at least certain level of optimization is necessary with respect to the shared resources. In order to optimize resource sharing, another cost parameter (avoidance cost, C2) can be introduced that quantifies the penalties associated with not sharing a link or node in the network. FIG. 9 is a flow chart of an embodiment of a method of the present invention for computing multiple backup paths where the links and/or nodes are partially disjoint and avoidance costs are also included. Similar to the methodology set forth above, prior-use penalty costs (C1) as well as sharing avoidance costs (C2) associated with the network resources are initialized (step 904) upon acquiring the network's topology (step 902) pursuant to a connection request. A working path is then computed for the ingress and egress node pair associated with the connection request (step 906). A new metric (C) based on a mathematical relationship between C1 and C2 (e.g., $C=C1*C2$) may be used for optimizing path computations. Thereafter, subsequent multiple backup paths are computed by successively updating one or both costs after each backup path calculation (step 908). As a result, the methodology not only attempts to avoid, to a partial degree, the links and nodes that have already been used in a working path or a backup path, but also involves computing of paths after taking into consideration various costs that penalize avoidance of resource sharing. These steps may be repeated until a predetermined number of backup paths is reached or when the network topology no longer sustains any additional backup paths between the ETE node pair (decision block 910). If additional ETE node pairs are available that require path computations, the working path and backup paths may be computed by utilizing the process flow set forth above, wherein link/node prior use penalty costs and resource-sharing avoidance costs are properly taken into account for each pair and each path computation (step 912). 8:32–9:4  <pre> graph TD 1002[MONITORING QUALITY OF NETWORK ELEMENTS (E.G., NODES AND LINKS) BY A NETWORK QUALITY MANAGER] --> 1004[DETECTING QUALITY DEGRADATION OF A PARTICULAR NETWORK ELEMENT] 1004 --> 1006[MONITORING TEMPORAL AND SPATIAL CORRELATION OF FURTHER QUALITY DEGRADATION EVENTS WITH RESPECT TO THE FIRST QUALITY DEGRADATION EVENT] 1006 --> 1008[APPLYING APPROPRIATE MULTIPLE BACKUP PATH COMPUTATION METHODOLOGY TO DETERMINE BACKUP PATHS BASED ON FAILURE PREDICTION] </pre> FIG. 10

Exhibit D1 – Invalidity of U.S. Patent No. 8,982,691 in view of Elie-Dit-Cosaque – U.S. Patent No. 7,352,703

Claim	Disclosure
	As a further improvement, the multiple backup path computation schemes set forth above may be provided with the capability so as to be dynamically invoked based on network quality, which in turn may depend upon spatial and/or temporal correlation(s) of failures, e.g., a link or nodal degradation event. For instance, a centralized or distributed entity (e.g., QM 110 associated with administrator node 106 shown in FIG. 1) may continuously or periodically or otherwise monitor the quality of network components and upon occurrence of a particular condition, a suitable multiple backup path technique may be activated to compute one or more backup paths. Referring now to FIG. 10, shown therein is a flow chart of an embodiment of a method of the present invention for implementing a multiple backup path scheme based on temporal and spatial correlation of degradation events that gives rise to a failure condition. As alluded to previously, a network quality manager is operable to monitor the quality of network components, e.g., nodes, links, et cetera (step 1002). Each component may be given a quality rating. For instance, a link could be given a rating with respect to an appropriate quality variable that is parameterized between 1 and 10. If the signal quality through that link is degraded or otherwise affected, or if the quality parameter is below a certain threshold, that condition exemplifies a “degradation event” in the network. After detecting the first occurrence of such an event (step 1004), temporal and/or spatial correlation of further quality degradation events is monitored with respect to the first event (step 1006). In one embodiment, a timer may be started with a duration in the order of a minute and all the subsequent degradations occurring on other links during the same time window may be used for defining a Shared Risk Link Group (SRLG). In other words, links that exhibit simultaneous degradation are more likely to fail at about the same time; which can help in early detection of multiple failures. To reduce the possibility of multiple failures, however, two links belonging to the same SRLG are not used for the same lightpath connection (i.e., spatial diversification). Once a degradation correlation profile is determined, an appropriate multiple backup path computation scheme (e.g., the complete link disjoint methodology) may be used to compute a predetermined number of backup paths based on failure prediction. 9:5–47
[6a] instructions for protecting the Primary LSP against dual failures, comprising:	See claim element [1a] <i>supra</i> .
[6b] instructions for establishing the Bypass LSP for the Protected Primary LSP having a Point of Local Repair	See claim element [1b] <i>supra</i> .

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Claim	Disclosure
node and a Merge Point node;	
[6c] instructions for obtaining the nodes traversed by an end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node;	<i>See claim element [1c] supra.</i>
[6d] instructions for generating a request to a path calculator using the nodes traversed by said end-to-end path of said Bypass LSP for a disjoint path connecting said Point of Local Repair Node to said Merge Point node;	<i>See claim element [1d] supra.</i>
[6e] instructions for receiving a response from said path calculator; and	<i>See claim element [1e] supra.</i>
[6f] in response to determining that a fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, instructions for signaling, to at least one other MPLS label switch router, said fully disjoint path as the Backup LSP to said Bypass LSP.	<i>See claim element [1f] supra.</i>
[7] A non-transitory machine readable storage medium as claimed in claim 6, wherein the instructions specify that said path calculator is a	<i>See claims 1, 2, and 6 supra.</i>

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Claim	Disclosure
constraint based shortest path first calculator.	
[8a] A non-transitory machine readable storage medium as claimed in claim 6, wherein in response to determining that the fully disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available,	<i>See claims 1, [3a], and 6 supra.</i>
[8b] in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is available, signaling, to at least one other MPLS label switch router, said partially disjoint path as the Backup LSP to said Bypass LSP.	<i>See claims 1, [3b], and 6 supra.</i>
[9] A non-transitory machine readable storage medium as claimed in claim 6, wherein in response to determining that a partially disjoint path connecting said Point of Local Repair Node to said Merge Point node is not available, signaling an error on the attempt to provide a Backup LSP.	<i>See claims 1, 4, and 6 supra.</i>

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Claim	Disclosure
[10a] A non-transitory machine readable storage medium as claimed in claim 6, wherein the instructions specify after said obtaining step further steps of: procuring a Shared Risk Link Groups (SRLG) associated with the nodes traversed by the end-to-end path of said Bypass LSP from said Point of Local Repair Node to said Merge Point node; and	<i>See claims 1, [5a], and 6 supra.</i>
[10b] providing said Shared Risk Link Groups as part of said generating a request step to said calculator for use in calculating said disjoint path.	<i>See claims 1, [5b], and 6 supra.</i>