US006654379B1

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

(10) **Patent No.: US 6,654,379 B1**
(45) **Date of Patent: Nov. 25, 2003**

(54) **INTEGRATED RING-MESH NETWORK**

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

(21) Appl. No.: **09/414,474**

(22) Filed: **Oct. 7, 1999**

Related U.S. Application Data

(60) Provisional application No. 60/103,531, filed on Oct. 8, 1998.

(51) **Int. Cl.**[7] **H04L 12/28**
(52) **U.S. Cl.** **370/406**; 370/223
(58) **Field of Search** 370/222, 223, 370/254, 258, 406, 407, 408, 224; 709/251, 252

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,179,548	A *	1/1993	Sandesara	370/406
5,515,367	A *	5/1996	Cox et al.	370/404
6,038,044	A *	3/2000	Fee et al.	359/119
6,226,111	B1 *	5/2001	Chang et al.	359/119
6,229,815	B1 *	5/2001	Huang et al.	370/437
6,385,201	B1 *	5/2002	Iwata	370/400

OTHER PUBLICATIONS

I. Sanice "Optimum Routing Designs in Self-Healing Communications Networks," Bellcore Paper, May, 1994.

* cited by examiner

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(57) **ABSTRACT**

Whether in a SONET or a dense-WDM (DWDM) transport environment, we can expect to see a continuance of the two main survivable architectures: ring and mesh. The differing advantages of these technologies has allowed both of them to find applications, although they are usually deployed and operate quite separately. To date, the problem of optimally combining ring and mesh technologies into a single integrated transport design remains largely unstudied. This patent document presents a planning principle and related optimization theory to strategically embed rings into a mesh network, with the purpose of obtaining a lower total design cost than that of either a pure-mesh or pure-ring design. The new design approach is based on a recently developed insight into the nature of spare capacity requirements in a mesh-restorable network. So-called "forcer" analysis identifies the spans that drive the dimensioning of spare quantities in the network. The main hypothesis is that strategic placement of rings onto these spans, can result in mesh sparing relief that more than pays for the cost of the rings. However, the very large number of possible ring placements and sizes, makes this a difficult combinatorial optimization problem. Both heuristic and Integer Programming approaches were used to solve the problem. Results show cases of hybrid designs that are 5 to 25% less costly than that of a pure mesh design, depending on the test network and the relative mesh-ring technology costs. The Integer Programming method worked well for networks with fewer nodes and spans, while the heuristic was needed to obtain good solutions for relatively larger networks.

6 Claims, 7 Drawing Sheets