Chapter 1

Design of High Capacity Survivable Networks

Varadharajan Sridhar, Management Development Institute, Gurgaon, India

June Park, Samsung SDS Company Ltd., Seoul, South Korea

Abstract

Survivability, also known as terminal reliability, refers to keeping at least one path between specified network nodes so that some or all of traffic between nodes is routed through. Survivability in high capacity telecommunication networks is crucial as failure of network component such as nodes or links between nodes can potentially bring down the whole communication network, as happened in some real-world cases. Adding redundant network components increases the survivability of a network with an associated increase in cost. In this chapter we consider the design of survivable telecommunications network architecture that uses high-capacity transport facilities. The model considers selection of capacitated links and routing of multicommodity traffic flow in the network that minimizes overall network cost. Two node disjoint paths are selected for each commodity. In case of failure of the primary path, a portion of the traffic for each commodity is rerouted through the secondary path. The methodology presented in this chapter can be used by the network designer to construct cost-effective high capacity survivable networks.
Optic fiber and high capacity transmission facilities are being increasingly deployed by Telecommunication companies for carrying voice, data, and multimedia traffic. Local (some times referred to as basic) telecom service providers are spending tens of billions of dollars on fiber-based equipment and facilities to replace or augment the existing facilities to provide high bandwidth transport. This has led to sparse networks with larger amount of traffic carried on each link compared to traditional bandwidth limiting technologies which deployed dense networks. One of such technologies is synchronous digital hierarchy (SDH) standardized by the International Telecommunications Union. SDH decreases the cost and number of transmission systems public networks need and makes it possible to create a high capacity telecommunications superhighway to transport broad range of signals at very high speeds (Shyur & Wen, 2001). Because of their sparse nature, these networks inherently have less reliability. Failure of a single node or link in the network can cause disruptions to transporting large volume of traffic, if alternate path is not provided for routing the affected traffic. Though backup links can be provided to improve the reliability of such sparse networks, it could increase the cost of the networks substantially. The challenge is to improve the reliability of the networks at minimal cost. Researchers have looked at methods of improving reliability of such networks. Detailed discussions on the importance of survivability in fiber network design can be found in Wu, Kolar, and Cardwell (1988) and Newport and Varshney (1991). Recently, vulnerabilities and associated security threats of information and communication networks have prompted researchers to define survivability as the capability of a system to fulfill its mission, in a timely manner, in the presence of attacks, failures or accidents (Redman, Warren, & Hutchinson, 2005).

Networks with ring architecture are also being increasingly deployed in high capacity networks to provide survivability. Synchronous optical network (SONET) uses a self-healing ring architecture that enables the network to maintain all or part of communication in the event of a cable cut on a link or a node failure. SONET networks are being increasingly deployed between central offices of the telecommunication companies and between point of presence (POP) of traffic concentration points. SONET-based transmission facilities are also being deployed increasingly to provide broadband facilities to business customers and government agencies. Operationally such self-healing ring networks divert the flow along an alternative path in the ring in case of failure of a node or link.

For a discussion of the use of rings in telecommunication networks, the reader is referred to Cosares, Deutsch, and Saniee (1995). Cosares et al. (1995) describes the implementation of a decision support system called SONET toolkit developed by Bell Core for constructing SONET rings. The SONET toolkit uses a combination of heuristic procedures to provide economic mix of self-healing rings and other architectures that satisfy the given survivability requirements. Chunghwa Telecom, the full service telecommunications carrier in Taiwan, has developed a tool for planning linear and ring architectures of high-capacity digital transmission systems (Shyur & Wen, 2001). The tool reduces planning and labor costs by 15 to 33%. Goldschmidt, Laugier, and Olinick (2003) present the case of a large telecommunication service provider who chose SONET ring architecture for interconnecting customer locations.
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