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Performance evaluation of survivable WDM based SANs in a metro ring network

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ABSTRACT

Storage area networks (SANs) are an essential part of enterprise computing today. There is no comprehensive business continuity plan without SANs in the picture. This paper proposes and evaluates network survivability of optical paths in wavelength division multiplexing (WDM) based storage area networks in a metro ring network. The paper begins with a background on network survivability in metro WDM ring network. Subsequently, the network and node architectures along with their medium access control (MAC) protocols are described. In this work, one link failure (a single cable cut) in metro WDM based SANs in a ring network architecture is considered. Performance evaluation for network survivability in metro WDM SAN is carried out by means of discrete-event computer simulation. Network throughput and packet delay are investigated. The network performance is evaluated for asymmetric (unbalanced) traffic scenarios under Poisson and self-similar traffic.

1. Introduction

Data (or information) is arguably an organization's most valuable asset. Enterprises could deal with remarkable financial and regulatory consequences if availability of the data (or information) is disrupted, even for only short period of time. Storage area networks (SANs) are an essential part of enterprise computing today to protect this asset. There is no comprehensive business continuity plan without SANs in the picture. SANs provide high availability and fast recovery from catastrophic disasters via data replication, alternate pathing and backup. SANs were initially designed to work within limited distance environments such as a campus. The effects of natural disasters such as earthquakes, fires and floods, power outage, and terrorist attacks could be severely destructive; hence, the need for extending SANs over large distances has become essential to protect data against loss or damage and to share storage resources among a greater number of users over large geographic areas. Some countries like the US have in fact adopted regulations that the data should be replicated and the replicated copies of the data should be kept in different places separated by large distances. A usual solution is to add a second SAN node in the network with identical capacity to the first one. Furthermore, demand for storage capacity continues to grow at nearly 60 per cent per year as a series of regulations – including Sarbanes–Oxley and the EU directive on data retention – require businesses to store more data for longer before archiving or deleting. These realities generate an insatiable demand for bandwidth and storage as never seen before. The challenge is to design a network which provides reliability, scalability in terms of distance and number of nodes, high throughput, and full accessibility to the replicated storage.

Photonic network technologies and wavelength division multiplexing (WDM) have become a technology of choice to increase network bandwidth in recent years and the trend is continuing. Due to its superior characteristics, WDM technology is not only utilized in backbone networks but has also started to be utilized in metropolitan area networks (MANs) [1]. This latest development makes it more and more feasible for WDM technology to be used in SANs to give SANs a more competitive, high-bandwidth, high-scalability and low-latency edge.

The unprecedented users demand and the advent of photonics technologies generate great opportunities for metro WDM based SANs. Optical storage area networking has started to receive attention. It is therefore of interest to explore systems and protocols that may enable WDM to be effectively used to enhance the capacity, access speed and capabilities of SANs.

Network survivability and disaster recovery are critical issues in metro WDM network based SANs as a single fiber cut may influence a huge amount of bandwidth in transmission and cause service interruptions to innumerable end users. Work on survivability in WDM optical networks has focused mostly on the recovery from a single link or node failure. This is primarily due to two main reasons: the most common failure in optical networks is cable cuts and it is easier to plan for the failure of at most one piece of equipment at a time [2].

In this work, one link failure, such as a single fiber cut, in metro WDM based SANs with two SAN nodes in a ring network architecture is considered. Network survivability of metro WDM based SAN is evaluated and studied by means of discrete-event com-

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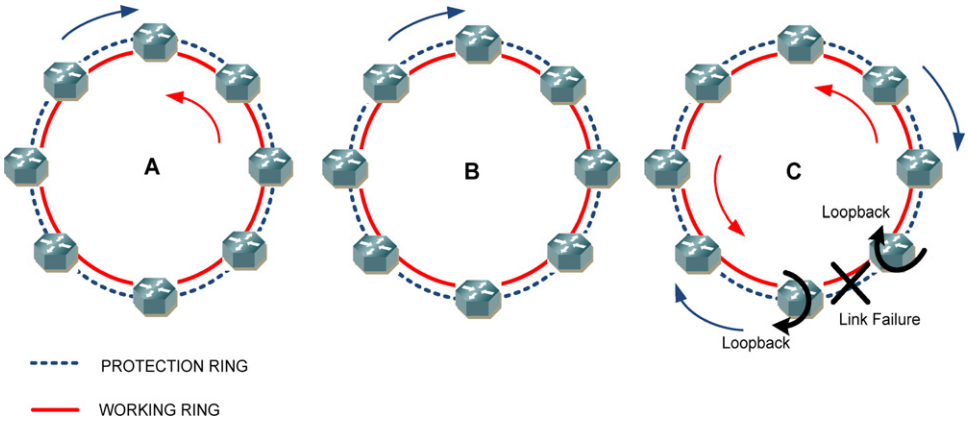

Fig. 1. The unidirectional path switched ring (UPSR) consists of a dual-fiber counter rotating ring (A). When a link failure is detected on the working ring, the UPSR detects it and reconfigures itself by switching to protection ring. If a single fiber link is at fault, then the ring without faults is used (B). If both fibers are at fault, then traffic is passed from one ring onto the other by looping back at the nodes adjacent to the fault (C).

puter simulation. Performance evaluation under Poisson and bursty self-similar traffic is considered. Network performance in terms of network throughput and packet queuing delay is evaluated with asymmetric traffic scenarios. Asymmetric traffic is considered in order to evaluate the impact of hot-node scenarios, for example where one server acts as a gateway, SAN access point, or as a database server.

Following the introduction this paper is organized as follows: Section 2 discusses network survivability in metro WDM ring network. Section 3 presents our system architecture, and introduces the MAC protocols. Performance analysis results from discrete-event simulation are given and discussed in Section 4. Finally, the paper is concluded in Section 5.

2. Network survivability in metro WDM network

Disaster recovery and network survivability such as protection and restoration in metro WDM SANs is very important for business continuity. Disaster recovery is one of the smart moves for anyone who wants to protect a valuable asset like data. The modern corporations run and live on data. A well prepared disaster recovery plan can play a significant role in a company's survival in the competitive world.

In essence, there are two common methods that have been proposed and implemented to provide resilience in optical networks: pre-design protection and dynamic restoration. In pre-design protection, the recovery effort from network failures is based on pre-planned schemes. Usually it relies on resources (fibers, wavelengths, switches, etc.) dedicated to protection purposes. In metro WDM SANs, the network can implement dual-fiber counter rotating link where one physical link is reserved for protection purposes. On the other hand, in dynamic restoration there is no reservation of resources at the time of connection establishment. When the failure occurs, the network has to select and utilize available resources such as fibers, wavelengths, switches, and so on during a restoration process. Automatic protection switching (APS) and self-healing ring (SHR) are two most common techniques in pre-design protection in ring-based network.

In this work one type of SHR, Unidirectional Path Switched Ring (UPSR) method is implemented and evaluated. In UPSR, there are two unidirectional counter-propagating fiber rings (working and protection). The traffic is forwarded to both fibers to create a 1 + 1 protection. The 1 + 1 protection provides the fastest restoration time and requires no signaling overhead for backup path establishment. When a link failure is detected on the working ring, the UPSR is able to detect it and reconfigure itself by switching to protection ring. If a single fiber link develops a fault, then the ring without faults is used. If both fibers on a span develop a fault, then traffic is passed from one ring onto the other by looping back at the nodes adjacent to the fault (see Fig. 1).

3. System architecture

The architecture considered is targeted for metro area ring networks. Fig. 2 shows a high-level view of the ring network. The network is dual-fiber (working and protection fibers) counter rotating WDM slotted ring, which is designed to interconnect access nodes (ANs) on a regional scale. Each AN has add-and-drop capabilities to access the ring slots and is used to link an access network to the ring. This can be realized by means of optical add-drop multiplexers (OADM).

There are two types of nodes in the network: the ordinary nodes and the SAN nodes. Each AN has add-and-drop capabilities to access the ring slots and is used to connect a local area network (or access network) to the ring. The vast majority of LANs throughout the world are based on Ethernet, and hence, in Fig. 2 ANs are connected to the access networks via GbE links. However, the network can equally use other medium access technologies.

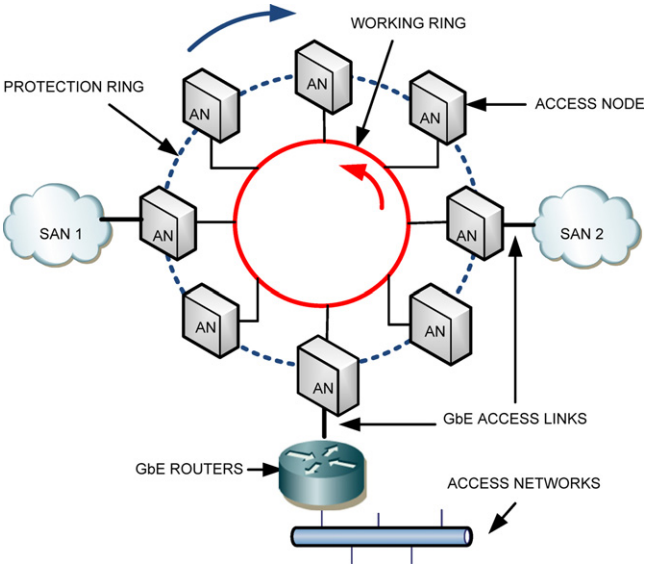

Fig. 2. Network architecture.