NETWORK LAYER MODELING OF WDM FIBER OPTIC NETWORK ARCHITECTURES FOR AEROSPACE PLATFORMS

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We use a proposed reference network architecture to investigate the fault tolerance of an avionics DWDM network. Our simulations show modest increases in the numbers of hops and packets lost for low number of line failures.

Introduction

WDM fiber optic networks are increasingly becoming interesting for aerospace platforms due to high data carrying capacity and lower weight compared to copper. Fiber optics is already in use for in-flight entertainment and other flight non-critical applications [1, 2], whereas flight critical applications, such as flight controls and navigation systems, are still placed on older and tested copper based networks. While fiber optics is a seemingly obvious candidate to replace copper for flight critical data as well, standards have to be generated and reliability thoroughly tested before being deployed due to the implications of failure. A part of this process has been initiated by SAE Avionic Systems Division with the launch of an effort to develop the Aerospace WDM LAN Standard AS-5659, which aims to specify the architectural requirements, as well as identifying and developing modeling tools. In this paper we describe an architecture developed for this process and some initial modeling results.

Architectural considerations

The network investigated in this work is meant to carry all types of traffic envisioned onboard an aircraft, including flight controls and other mission critical information as well as less-critical information. But not only does the network have to accommodate the traffic presently on an aircraft; it needs to be able to handle future equipment with significantly increasing traffic demands over the lifetime of the airframe. One of the unique characteristics of a WDM optical network for avionics is the necessity for a high degree of fault tolerance and redundancy, especially when including flight critical data such as flight controls. The network investigated in this paper must be able to sustain 3 faults and still be operable, which in essence dictates the number of connections each node in the network must have. A network architecture suggested by these requirements is shown in Figure 1. It is a meshed network with a maximum of 256 nodes, full interconnectivity, supporting mixed digital and analog transmission with each line capable of handling greater than 1 Tbps using DWDM. The network in Figure 1 is mainly focused on the interconnectivity of the switching nodes; however, the end goal is to ensure the traffic integrity from termination point to termination point, i.e. from radar to radar screen or from cockpit flight control to flight control actuator. Figure 2 illustrates the logical connection map with node numbers.

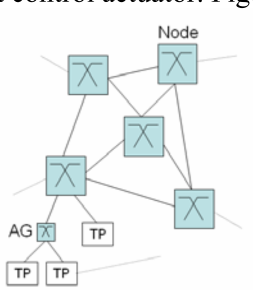

Fig. 1. Meshed network with interconnected switching nodes and terminations points (TP, end user) and aggregation points (AG) for low traffic volume termination points.

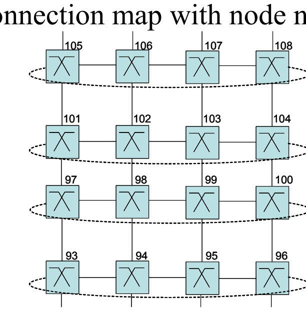

Fig. 2. Node logical arrangement.

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Computing the number of hops required on a network with 3 faults yields a slightly higher maximum hop number, as expected due to the extra roundtrip distance. This is illustrated in Figure 3 below. This corresponds to the fact that the cut connections increase the number of hops slightly due to the longer routes the traffic has to take while circumventing the failure points. This is also seen from Figure 3, showing the packet loss in % and the maximum number of hops versus the number of line failures incurred. For a low number of line failures, the packet loss is extremely low, whereas as expected, it increases with the number of failures and so does the number of hops.

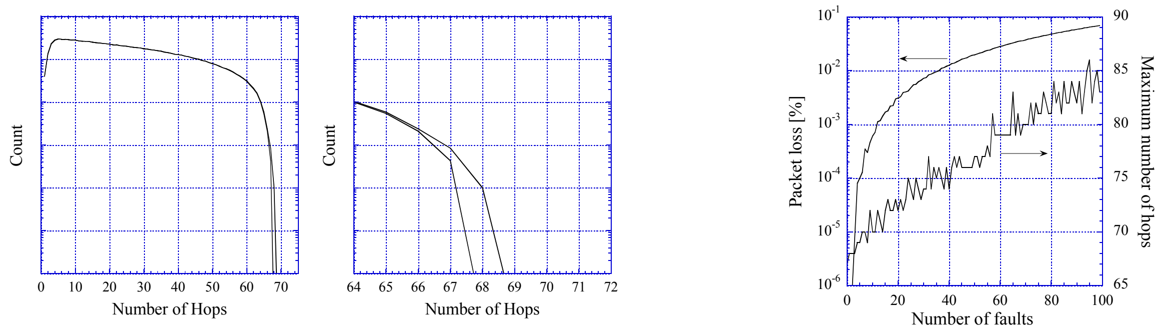

Figure 3. Hop count distribution with 3 faults and without faults (left) and packet loss in % and maximum number of hops versus the number of line failures (right).

There are a number of other considerations to take into account for this network and one is that of utilization. Currently, it is assumed that the network is over engineered and there will always be resources available to reroute traffic in case of a fault. Depending on the actual realization of the network, this might not always be the case and this has to be taken into account in the simulations as well. Results of these analysis will be presented during the conference.

Conclusions and Future Work

To address the requirements of an avionics WDM LAN, a reference architecture has been proposed and evaluated through network-layer simulations. In the future switching transients will be investigated as well as restoration under full network utilization. Through the work of the SAE ASD AS-5659 group more detailed investigations will also be proposed and initiated.

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References

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