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A WDM Optical Network for Avionics

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Abstract

Fly-by-light has been a research and development area for the last 15 years, and much progress has been made in many areas involving the components technologies. The next phase of developments in fly-by-light involves systems and architectural issues together with parameters that requires integration of such components in the next generation avionics and Fly-By-Light systems. Such deployments of optical networking technology for all communications, command, and control functions within an aircraft are compelling. Moreover, Wavelength Division Multiplexing (WDM) is particularly useful for supporting diverse applications in a systematic and comprehensive manner. This paper describes a basic WDM architecture utilizing 1) passive optical coupling for distributed signal collection (multiplexing), 2) passive optical splitting for signal distribution and separation (demultiplexing), and 3) centralized processing of information bearing signals utilizing multi-processors for demanding applications or multi-programmed computers for less demanding functions. Standardized WDM interfaces on generic processor cards in the centralized locations support a variety of network structures.

Key considerations in the chosen architecture are: 1) built-in performance monitoring, 2) automatic protection switching for fault tolerance, 3) accommodation of existing applications, and 4) extensibility to future, unknown applications.

Summary

Optical transmission technology offers multiple attractions for avionic networking. High bandwidth, light weight, EMI immunity, and avoidance of electrical spark generation are principle attractions. Supporting the myriad of sensor, control and communications functions within an aircraft with a single unified network adds the additional promise of further minimizing total system weight and volume. Realizing theses advantages requires a robust and flexible networking architecture that supports a variety of signal types and data rates. Wavelength Division Multiplexing (WDM) is particularly suited to transmission of very different signal types (digital or analog) in a transparent manner. WDM is most advantageous if passive components can be utilized for collecting and distributing individual signals throughout the airframe. A particular challenge for the use of passive components is the establishment of networking practices that eliminate or minimize the need for optical amplification.

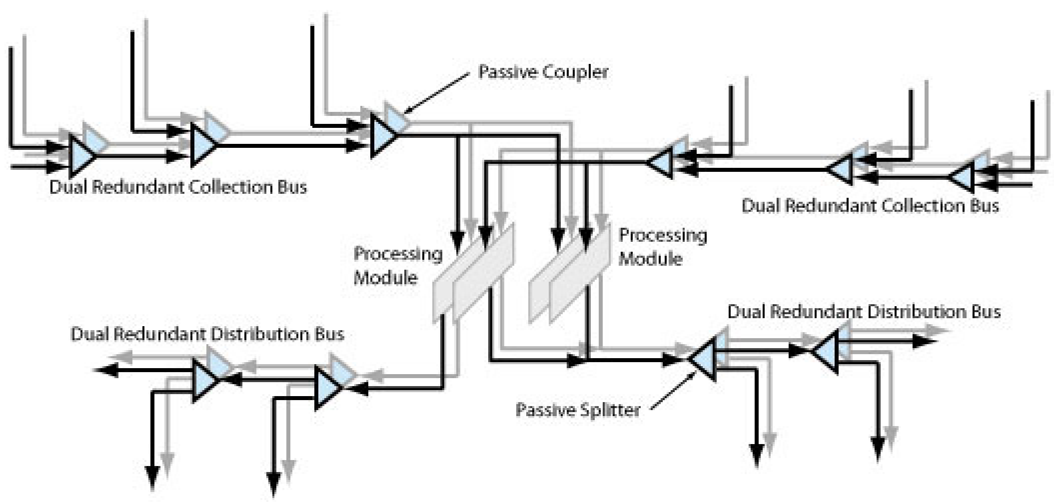
Directive optical couplers provide distributed access (multiplexing) to a single fiber or possibly a small number of fibers that home in on one or more processing nodes. Ideally, all of the wavelengths carried in a fiber should be dropped and processed at a single node. Nevertheless, WDM drop, insert or pass capabilities will be provided for those situations wherein multiple physical locations of processing nodes is desirable. Optical amplification is available in processing nodes that pass one or more wavelengths onto another location.

In a manner similar to the collection process, passive optical splitters are used to separate individual wavelengths (demultiplex) at multiple points in a fiber path. Use of wavelength dependent splitters can minimize signal loss to outlying points of distribution.

A key feature of the proposed architecture is use of standardized WDM access device located on processing cards of centralized nodes. A WDM access device is a compact module with integrated WDM mux/demux, local signal access, signal amplification, and signal relay for multi-processing or multi-node signal distribution. A single signal (wavelength) can be delivered to one node or multiple nodes, as necessary.

The architecture supports two levels of signal health monitoring and protection switching: Catastrophic failures are detected in the access modules which immediately perform the necessary protection switch to a peer access module. Soft failures (e.g. dribbling bit errors) are detected within the next higher communication layer (data link layer) above the access module layer. This layer can also trigger a protection switch when the situation warrants such.

The processing equipment is implemented with multiple, hardware-identical processing boards (computers). Differentiated functionality is provided through software configurability. If necessary, multiple processors can cooperate in processing a single input signal or a single processor can process multiple signals (e.g. wavelengths) depending on the processing loads of the applications. In addition to performing application dependent processing, the processing boards continuously monitor the health of the transmission facilities and other networking hardware elements.



Proposed Avionics Optical Network