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A WDM/Optical-CDMA (WDM/O-CDMA) Concept for Avionics Integration

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Abstract: We describe a concept where WDM and O-CDMA share a set of discrete wavelengths and components while using similar modulation formats. O-CDMA acts as a channel multiplier. Experiments show the feasibility of >2X channel multiplication.

WDM is envisioned as a key technology for future avionics integration and there is activity towards standardizing WDM LANs for this application [1]. O-CDMA has been described as another candidate for avionics integration [2]. Our interest is in a WDM/O-CDMA hybrid concept that takes advantage of the strengths of both multiplexing schemes, with the addition of O-CDMA acting as a channel multiplier (as will be described shortly). We also stress that both multiplexing schemes shall be based on the same WDM components, and the modulation formats are as similar as possible. This leads us naturally to 2D O-CDMA codes, implemented as wavelength/time (W/T) codes [3]. To make the WDM and O-CDMA modulation formats as similar as possible, "tall" matrices are preferred, that is, the W/T codes should be based on few time slots and many wavelengths. W/T codes use intensity modulation/direct detection (IM/DD). Low coherence light sources are preferred to minimize beat noise interference and to support complete asynchronous operation [4,5]. Alternatively, the received power can be increased [5].

To illustrate the channel multiplication of W/T codes, consider the case where 16 WDM wavelengths (on the ITU grid) are available on a bidirectional bus [6]. Then the wavelengths can be partitioned into those assigned to WDM and the complementary subset to O-CDMA (see Figure 1a). This partitioning is completely arbitrary because the W/T codes can be designed around any number and selection of wavelengths (and, particularly, not restricted to Prime numbers). The possible partitioning solutions are shown in Table 1, including the number of asynchronous communication channels that result (shown along the diagonal). The table shows explicitly the channel multiplication of O-CDMA, independent of the individual mix of WDM and O-CDMA channels.

In order to test the concept of O-CDMA as a channel multiplier, an O-CDMA Technology Demonstrator (TD) was designed and developed. The TD is based on eight WDM ITU grid wavelengths (100 GHz spacing) and 32 8x4 matrix codes (a 4x wavelength or channel multiplication in the pure O-CDMA case). The TD, whose architecture is shown in Figure 1b and 1c, is implemented entirely with commercial-off-the shelf (COTS) components (additional details can be found in references [3, 5]). Figure 2 shows bit-error-rate (BER) measurements with 16 of the 32 O-CDMA channels operating concurrently, each at a signaling rate of 1.25 Gsymbols/s. The figure shows that a BER<10^-11 is feasible and it demonstrates that at least a 2x channel multiplication possible with 2D O-CDMA. In conjunction with the 16 WDM channel bi-directional bus [6], this stage of development would provide 24 1.25 Gsymbols/s asynchronous channels (eight WDM and 16 O-CDMA), a 1.5x channel multiplication. In the near term the TD will be populated with 24 and 32 O-CDMA channels (giving a 2x to 2.5x channel multiplication factors).

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Table I. Number of Concurrent Channels (Diagonal) Available in a WDM/O-CDMA Concept Based on 16 Wavelengths.

		Number of O-CDMA Channels and Dimensions {rows x columns (time slots)} of W/T Matrix Codes					
		0	4; 1x25	16; 4x7	32; 8x4	48; 12x3	64; 16x3
Number Of WDM Channels	16	**16**	-	-	-	-	-
	15	-	**19**	-	-	-	-
	12	-	-	**28**	-	-	-
	8	-	-	-	**40**	-	-
	4	-	-	-	-	**52**	-
	0	-	-	-	-	-	**64**

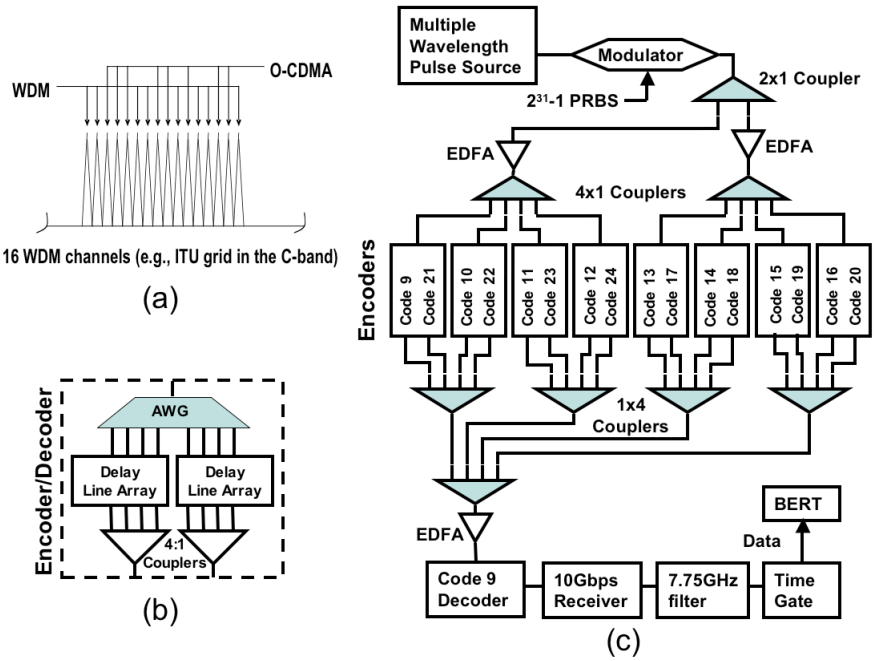

Figure 1: (a) Example arbitrary partitioning of 16 wavelengths for WDM and O-CDMA functions. (b) O-CDMA encoder and decoder set-up. (c) Set-up of the technology demonstrator using the encoders and decoders.

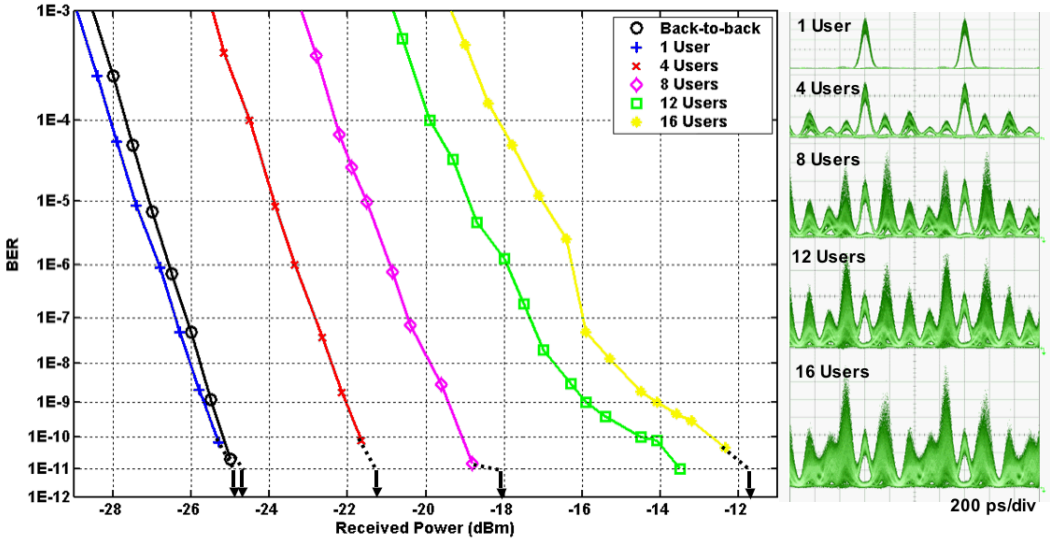

Figure 2: Bit-error-rates and eye diagrams produced by the technology demonstrator.