Monitoring Optical Fiber Dispersion

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Background
Rapid growth of Internet and wireless applications is beginning to outgrow the capacity available on the existing information superhighway consisting of conglomeration of optical fiber and amplifiers under the ground and in the ocean. The increasing demand for high bandwidth is directly related to the increase of the bit rate, which makes these systems very sensitive to optical fiber impairments, such as chromatic dispersion and nonlinearities.

Purpose
The major challenge in these optical networks is that the optical fiber impairments are not constant but in fact vary with time due to variations in some parameters such as; the information transmission path distance, and the temperature etc... One of the most viable solutions would be monitoring the signal quality in the system in order to respond to variations and dynamically compensate for the impairments. Our research revolves around the study of optical fiber networks in terms of monitoring and automating the network to increase its level of reliability and operability.

Design/Method
We used the central limit theorem to purposefully approximate the distribution of the received binary low and high bits using Gaussian distributions. We refer to this technique as Bit-stream Distribution Approximation (BDA). BDA monitors the chromatic dispersion by analyzing the relative distributions of the high and low bit rails in a 10.7 Gbps binary non-return-to-zero (NRZ) intensity modulated signals. We used the mean statistic of these distributions to model the residual chromatic dispersion within the optical fiber.

Results
Using BDA, the distributions’ mean and variance were evaluated for varying combinations of dispersion, power, and transmission distance. The primary observation from evaluating the mean of the distributions is that the mean values follow a polynomial function of the input power. The mean also exhibits a consistent linear increase with respect to dispersion. Therefore, we derived an empirical model to evaluate the residual dispersion in an optical fiber using the mean of the received low bits, power and transmission distance. This derived model estimates the dispersion using the mean of the distribution with an estimation error that does not exceed ±3%.

Conclusions
In conclusion, a technique to monitor chromatic dispersion utilizing Gaussian distribution approximation of the high and low bits in a binary NRZ optical network called Bit-stream Distribution Approximation (BDA) was discussed. The value of chromatic dispersion was estimated by evaluating the mean, and variance of the received bits’ distributions. We analyze a 10.7 Gbps terrestrial optical network. Our proposed technique has a constant chromatic dispersion operation range of 900ps/nm. Based on this proposed technique, an empirical model to estimate the dispersion was derived. This model estimates the dispersion using the mean of the distribution with an estimation error not exceeding ±3%.