PERFORMANCE ANALYSIS OF OPTICAL CODE DIVISION MULTIPLE ACCESS TECHNIQUE FOR METROPOLITAN AREA NETWORK

ABSTRACT

Optical code division multiple access (OCDMA) allows signal to be transmitted in an asynchronous manner, and promises high flexibility and simplicity with considerable security. OCDMA harnesses an enormous bandwidth that provides high spectral utilization and efficiency to support multiple, simultaneous active users. However, this multiple access technique also has impairments such as multiple user interference (MUI) and signal dispersion over distance. Thus, traditional metropolitan area network (MAN) must be developed by considering system performance optimization.

Optimization is typically achieved by increasing code length and system complexity, or by applying a high level of medium access control (MAC) supervision. Numerous code set developments have been proposed to overcome the aforementioned impairments. However, the proposed code sets have not been demonstrated in an actual optical system that supports multiple users, particularly in a MAN, which has various noise sources and MUI effects. Thus, the feasibility of these code sets cannot be verified with absolute certainty. Conventional OCDMA architecture and encoding stage also exhibit various deficiencies, including rigid synchronization, fiber delay line (FDL) accuracy issues, stability resulting from environmental fluctuations, high costs, difficulty in fabrication, lack of compactness, and spectral resolution issues. In this work, an optimized model is presented as an enhanced solution to the limitations of the existing approach to be applied in a MAN.

This work proposes an integrated formulation that can be realized by three key aspects: differential modulation, optimal optical code design, and the MUI reduction. This work also addresses the development of an optimized OCDMA architecture that includes a transmitter and a receiver, designed for a MAN. This thesis presents new grating configurations for fiber Bragg grating (FBG) and investigates the possibility of achieving system performance optimization in a MAN while considering the effects of various noise sources, non-linearity, and dispersion. The encoding and decoding schemes are designed based on the bipolar phase shift by using FBG. This work presents optimal grating configurations that embodies the orthogonality aspect and demonstrates consistent performance in different scenarios: intensity modulation-direct detection, external modulation, non-return-to-zero (NRZ)-differential phase shift keying and NRZ-differential quadrature phase shift keying, thus obtaining satisfactory agreement with the theoretical analysis. This work requires minimum MAC supervision and eliminates the need for FDL for queuing, which is in line with the requirement of real-time delivery.

System optimization is achieved by using an integrated formulation that embodies the differential modulation approach, optimal grating configurations, and the MUI reduction. This optimization approach is verified by the design parameters, and enhancement is demonstrated by the performance parameters, which are over 2, 4, 8, and 12 users at bit rates of 1.25 Gbps, 2.5 Gbps, 10 Gbps, and 40 Gbps, respectively, spanning from 5 km to 100 km. This integrated optimization formulation extends the maximum allowable single-mode fiber span, which offers error-free transmission for BER $\leq 10^{-9}$ and accommodates higher aggregated traffic capacity than the conventional approach.