Title of the Ph.D. dissertation: "Design and Study of LDPC Codes for Free-Space Optical Communication System

Abstract: Free-space optical (FSO) communication is the next facet for designing future-generation telecommunication networks. Error control codes (ECCs) are commonly used to enhance reliability. In this dissertation, we analyze the threshold and the BER performance of an asymptotically long-length LDPC code with the density evolution analysis of the belief propagation (BP) algorithm. Determining the FSO channel threshold is tedious as the density of the log-likelihood ratio cannot be assumed as Gaussian. It, thus, requires testing different values of SNR as a possible threshold systematically. Therefore, we propose the divide and conquer algorithm. The threshold depends on the degree distributions, channel state information (CSI), and the turbulence level.

To achieve the threshold close to the FSO channel's capacity, we require an optimum degree distribution for the LDPC codes. We derive the degree distributions of irregular LDPC codes by optimizing either SNR or code rate. We also derive the capacity and BER performance of the LDPC codes in receiver diversity and multiple-input multiple-output systems.

In the dissertation, we propose a novel and effective scheme, called the channel assisted coding (CAC), wherein we combine the degree of bits with the channel coefficient. With the CAC-LDPC coding system, we alleviate any interleaving induced latency. The MATLAB simulations show that CAC-LDPC achieves a coding gain of around 13.7 dB with 32 spatial links, compared to the LDPC interleaved systems in strong turbulence. We propose three analytical models to characterize the performance of CAC-LDPC. The analytical results are supported with the simulation study.