Experimental Investigation of Coherent and Incoherent Interferometric Noise in 2-D Optical CDMA Networks

Katherine Thompson, Y. Deng, M. P. Fok, and P. R. Prucnal
Department of Electrical Engineering, Princeton University
Email: katiet@princeton.edu

Introduction

- Optical Code Division Multiple Access (OCDMA) networks have the potential to accommodate many users since multiple signals can be sent on one fiber. These networks can be applied in high speed systems to transfer large amounts of data over kilometers of fiber.
- The OCDMA system used was a 2D wavelength-hopping time-spreading approach that divides both the frequency and time spectrums into slots in order to give users unique codes.

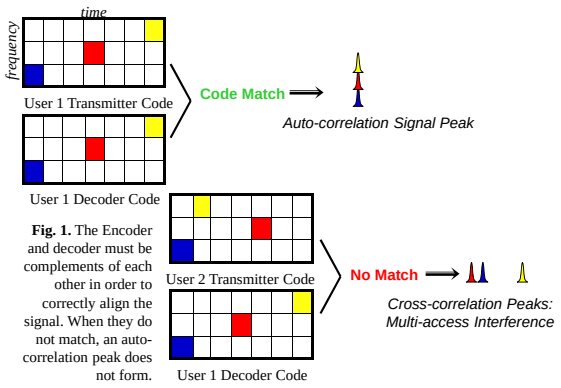

Fig. 1. The Encoder and decoder must be complements of each other in order to correctly align the signal. When they do not match, an auto-correlation peak does not form.

- When a user's code implements a wavelength that is same or similar to another user's and a cross-correlation peak of the interfering user lines up with the main user, those wavelengths beat together and a phenomenon called interferometric noise occurs.

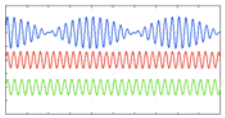

Fig. 2.
Beating between users
Main User
Interferer

- Although there have been many theoretical studies on the interferometric noise in OCDMA networks, there have not been extensive experimental studies of the prevalence and effects of different types of beat noise.

OUR EXPERIMENT: comparing the coherent, partially coherent, and incoherent interferometric noise in a two-user system and investigating the extent to which beat noise degrades a signal.

Experimental Setup

- The binary data is modulated to the signal in the electro-optic modulator (EOM) and the data signal is split to become the two users and travels through two fiber Bragg grating (FBG) encoders.
- In between the encoder and decoder we added a polarization control and delay lines in order to align the auto-correlation and cross-correlation peaks of the two users and optimize the noise.

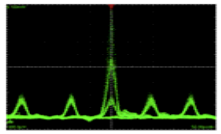

Fig. 3. Example of auto-correlation and cross-correlation peaks aligned and interferometric noise optimized.

- The split signal allowed us to add a 20-m fiber to one of the users for the partially coherent case and a 1986-m fiber for the incoherent case.
- The decoder, which both signals were realigned with, has the complementary delays as encoder 1. This caused the signal of the user to align as one large peak (auto-correlation peak), and the signal of the interferer to align as 4 separate smaller peaks (cross-correlation peaks).

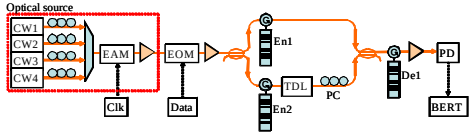

Fig. 4. Optical CDMA network setup. CW: continuous wave laser, EAM: electro-absorption modulator, EOM: electro-optic modulator, En: FBG encoder, De: FBG decoder, PC: polarization controller, TDL: tunable delay line, PD: photodetector, BERT: bit error rate tester.

Fig. 5. RF Input

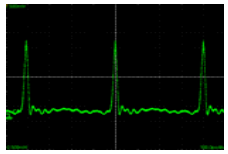

Fig. 6. Optical Output

Results

Histograms of Coherent, Partially Coherent, and Incoherent Noise - for lasers with 33MHz linewidth

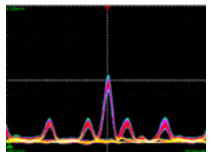

Fig. 7. Signal

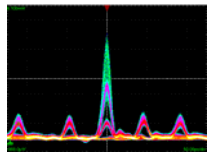

Fig. 8. Incoherent- 1986m

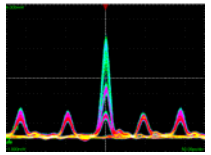

Fig. 9. Coherent- 1 bit shift

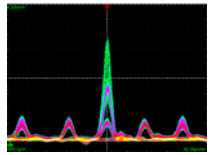

Fig. 10. Partially Coherent- 20m

- In fig. 7. the peaks of the two users are not aligned and the noise is minimal. In figs. 8-10, the peaks are aligned and there is much more noise compared to fig. 7. This noise is the interferometric noise and it severely degrades the main user's signal.

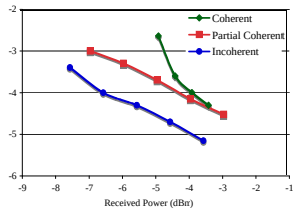

Fig.11. Bit Error Rate (BER) Measurements

CONCLUSION: The figures above demonstrate the prevalence of coherent, partially coherent, and incoherent beat noise in a two-user OCDMA network, indicating that interferometric noise is a significant part of the noise and cannot be ignored when using OCDMA systems.