Introducing CWDM for 40Gb/s and 100Gb/s Ethernet to Engineering Technology Curriculum

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Abstract

Since the approval of the 40Gb/s and 100Gb/s Ethernet standard (IEEE 802.3ba) in 2010, 4 x 10Gb/s channel coarse wavelength division multiplexing (CWDM) and 4 x 25Gb/s channel CWDM have been adopted and put into practical use as a standard for transmission of data streams over a 10km or 40km single mode optical fiber. To keep students' knowledge and skills current with the new technology development and prepare them to succeed in today's fast paced world of electronics and communications, an existing course has been revised and updated to include CWDM principles and their implementation examples in the curriculum. Challenges to include CWDM in the current curriculum include the fact that a different set of knowledge and skills on optical sources, photodetectors, amplifiers, etc. need to be integrated into the current one-semester course that only briefly introduces optical fiber communications. We present in detail the challenges and the methods we use to overcome them.

Keywords

CWDM, 100Gb/s Ethernet, 40Gb/s Ethernet, Telecommunication.

Introduction of DWDM and CWDM

Dense wavelength division multiplexing (DWDM) is a technology that expands the capacity of a network by multiplexing optical signals having different wavelengths on a single optical fiber. Combined with optical amplifiers, DWDM allow expanding capacity of an existing optical fiber infrastructure by upgrading the multiplexers and demultiplexers at each end without having to reconstruct the backbone network. DWDM has been used mainly in long hall and ultra-long hall backbone networks. Coarse wavelength division multiplexing (CWDM) and DWDM share the same multiplexing mechanism but differ in number of channels, channel spacing, and the ability to amplify the multiplexed signals in the optical space. CWDM has fewer channels and larger channel spacing compared to DWDM. Because wideband optical amplification for CWDM is not available, only up to tens of kilometers' optical propagations can be achieved. Therefore, CWDM has a good fit to access networks and many metro/regional networks. CWDM has been adapted by IEEE as the 40Gb/s and 100Gb/s Ethernet standard[1].

Course Revision

The Department of Engineering Technology at the University of North Texas offers Master of

Science in Engineering Technology (MSET) degree in three concentrations, namely Electrical Engineering Technology, Mechanically Engineering Technology, and Construction Management. The Introduction to Telecommunications course MSET5320 serves all MS students. Therefore, there was no prerequisite course requirement to register the course. We normally spent first two to three weeks for leveling lectures to prepare students ready for the course.

Since the Spring of 2016, we have added a prerequisite course (Introduction to Electronic Communications or equivalent) to the course syllabus as the first step of the course revision. So, we can save two to three weeks that had been spent for leveling, and dedicate them to the newly introduced materials.

Specifically, we devote the saved time to introduction of fiber optic systems, optical fiber structure and waveguiding principles. We then rearrange the orders that the chapters of Ethernet and Optical Communications are introduced as following:

a. Introduction to fundamentals of networking
b. Local-area networks
c. Ethernet
d. Optical principles and optical communication systems
e. Fiber-optic structure and waveguiding principles
f. Optical transmitters and receivers (including photodetectors and amplifiers)
g. Passive optical networks
h. 40Gb/s and 100Gb/s Networks/Ethernet

Wavelength division multiplexing (WDM) concept is introduced in the “passive optical networks” section to prepare students ready for introduction to 40Gb/s and 100Gb/s Ethernet. We then introduce the 40Gb/s and 100Gb/s Ethernet through an example that uses 4 x 10Gb/s channel CWDM and 4 x 25Gb/s channel CWDM. In 40Gb/s and 100Gb/s Ethernet, an optical transmitting module multiplexes four channels and transmits the multiplexed channels, while an optical receiving module receives multiplexed channels and separates them into individual channels. We focus on introducing the key components of the optical transmitting and receiving modules, i.e. transmitter optical sub-assembly (TOSA) where electrical-optical conversions of four channels and wavelength division multiplexing are performed; and receiver optical sub-assembly (ROSA), where wavelength division demultiplexing and optical-electrical conversion of the four channels are performed.

To help students understand the mechanism of TOSA and ROSA without doing experiments, we first introduce the following concepts: inside the TOSA, an externally modulated laser (EML) that combines a distributed feedback (DFB) laser diode with an electro-absorption modulator (EAM) on a single Indium Phosphide (InP) based chip is used for each one of the 10Gb/s or 25Gb/s channels for electrical-optical conversion. The ROSA consisting of a planer lightwave circuit (PLC) based CWDM demultiplexer and a four-channel photodiode array for optical-electrical conversion. After introduction to the concept, students receive a research paper as reading assignment. The paper is discussed in the following lecture session to help students connecting what they have learnt in class to the real world application; and fully understand the roles of TOSA/ROSA in CWDM and the role the CWDM plays in the 40Gb/s and 100Gb/s Networks/Ethernet.

Summary

We have revised an existing Engineering Technology curriculum to include CWDM for 40Gb/s and 100Gb/s Ethernet. The revised course was taught first time in the Spring 2016 and the overall students feedbacks are positive. We teach the course second time in the Spring 2017 with minor modifications and the student feedbacks are forthcoming. In the future, we plan to add a semester-long simulation project (e.g. using Optiwave software for WDM optical system design) to further enhance student learning experiences.

References

1 "IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet Task Force," official web site, IEEE, 19th June 2010, Retrieved 9th January, 2017.

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Shuping Wang received the B.S. degree in electronics engineering from Peking University, Beijing, China, in 1982 and the M.S. degree in physics from the Georgia State University, Atlanta, GA, in 1990 and the Ph.D. degree in electrical engineering from the University of Alabama in Huntsville, Huntsville, AL, in 1996. She is an Associate Professor of engineering technology with the University of North Texas, Denton, TX. Her research interests include optical design, fabrication, and packaging for WDM networks.