Designing Modern Optical Transport Networks

Course Description

Fiber optic systems are a key part of new communications services. Their success depends upon good design. This course provides a basic understanding of Fiber Optics, describing different Fiber types, the construction of point to point Fiber links, splicing, impairments and basic link design. It will examine the selection of wavelengths to use, and the use of multiple wavelengths in Course and Dense Wavelength Division Multiplexed systems. It will then provide an understanding of how these optical systems can be deployed using Remote Operation Add Drop Multiplexing Applications. Throughout the course students will undertake workshop exercises in order to be able to apply the knowledge learned.

Modern carrier networks must deliver reliable communications services that are secure and match the growing speed and capacity demanded by their customers. During the 20th Century we saw the growth in universal voice and this led to the development of SONET technologies based on Time Division Multiplexing technology. This has been used for early Internet services but these would benefit from packet based asynchronous designs and much higher data rate. 21st Century networks demand has been shaped by the inexorable growth in multimedia, social media and mobile services. Carrier Transport Networks must match the current demands with the right technologies delivered flexibly enough to adapt to the ever changing pattern of user demand. They must also be delivering service to the right place and at the right price.

This course is aimed at designers. It will be valuable to all those that want to be aware of the key sills of design, within the context of building new Transport Networks for tomorrows carrier services. These will raise the typical single wavelength 10 Gbit/s systems to 100 Gbit/s on Dense Wavelength Division systems carrying over 40 wavelengths per fiber.

While this is mainly concerned with long distance, high bandwidth core services, it is important to be aware of where and how the services will eventually be delivered. In the 1990s there was a massive grown in SONET and ATM technology within Transport Networks. However by the end of the 1990s it was realized that ATM was an expensive mistake as Switched Optical Ethernet offered a more powerful and cheaper solution. Also that SONET, optimized for voice services, was probably not the optimal solution either.

This course examines the demands which we are likely to place on our next generation of Transport Networks, identifies the options currently available for delivering reliability, security, aggregation flexibility, routing, switching and management. It then provides an approach to designing networks using standardized metrics to deliver services matching current and predicted future demand profiles. In-class exercises will uncover the key statistical techniques for estimating and prediction of future demand and confidence intervals. Using simple spread sheets and modelling students will learn from practical exercises how to design services to match their particular carrier network needs.

These techniques will then be applied to consider the design of carrier networks using Optical Transport technologies.

Students Will Learn

- **Identify the key metrics needed for Transport Network Design**
- **Estimate current and future service demand**
- **Apply key statistical prediction techniques to extract confidence intervals for designs**
- **Produce a design specification for a Fiber Optic Network Service**
- **Select the correct kind of Fiber links to match application requirements**
- **Specify the Physical Plant Layout**
- **Determine Fiber, Splicing, Termination, Testing and Troubleshooting procedures**
- **Calculate Link Loss, throughput and availability of the finished service**
- **Apply designs to ROADM and Wavelength Division Multiplex applications**
- **Deploy aggregation and topology selection to deliver the required reliability**
- **Select the optimal level of switching for the required services**
- **Match operational control, management and provisioning to the network needs**
- **Appreciate how migration from existing services can be achieved**
- **Ensure designs match the current and likely future needs**

Target Audience

Network designers, Project Managers, Infrastructure design professionals, Service and system engineers wishing to appreciate the design of services.

Course Outline

Module: 1. Fiber Optic Applications: Design Process

Appreciating What Fiber Optics Can Do

Identifying the Requirements

Key Network Parameters

Producing a Link Specification

Proving the Design Meets the Specification

Installing, Testing and Troubleshooting Procedures

Module: 2. Fiber Plant

Operational System Parameters

Fiber Optics Design Principles

Optical Sources and Modulation

On-Off Keying (OOK) transmission

Coherent modulation

Vertical Surface Emitting Lasers (VCSELs),Lasers

Fiber Types and selection

Multimode

Restricted Mode Launch Bandwidth

Laser Optimized Multimode

Single-mode

Fiber cable construction

Course Wavelangth Division Multiplexing (CWDM)

Dense Wavelength Division Multiplexing (DWDM)

CWDM vs DWDM performance and cost comparison

Workshop 1: Selecting Fiber Types

Deploying Wavelength Division multiplexing and Switching options

Hardware Selection Factors

Connectors and Splicing Options

Core Network Solutions

Intermediate and Metro Network Cross Connect

Wavelength Division Multiplexing

Power consideration in Multiplex solutions

Repeaters

Access Solutions: PON, FTTB, FTTC, FTTH

Workshop 2: Plant Specification for Wavelength Division Multiplexed system

Module: 3. Calculating Key Design Parameters

The Design Metrics

Selecting the values and the bounds

Accumulating and estimating aggregate loads

Predicting future load changes

Matching User Requirements to Transport Loading

Identifying service protection requirements

Theory And Principles of Fiber Optics Link Budgets

Cable Construction

Recommended Cable Types

Cable Selection

Termination Methods

Fusion Splicing Methods

Mechanical Splicing

Loss Analysis

Link Loss Calculation

Cost Comparison Model

System Redundancy and Availability

Workshop 3: Point to Point Link Calculation

Module: 4. Selecting the Right Technology Solutions

Availability and reliability

Physical and Logical Network Topologies

Add Drop Multiplexing

Physical Plant Layout: Fiber Counts/Types

Operational Service Requirements

Deciding how the Transport Service Will be Controlled

Configuration and Provisioning

Service protection considerations

G.8081/Y.1353 Definitions and Terminology for Automatically Switched Optical Networks (ASON)

G.807/Y.1302 Requirements for the Automatic Switched Transport Network (ASTN)

G.8080/Y.1304 Architecture for the Automatic Switched Optical Network (ASON)

Module: 5. Optical Transport Physical Transmission

Optical transport network interface structure

Multiplexing/mapping principles and bit rates

Optical transport module (OTM-n.m, OTM-nr.m, OTM-0.m)

Physical specification of the ONNI

Optical channel (OCh)

Optical channel transport unit

Optical channel data unit

Optical channel payload unit

OTM overhead signal (OOS)

Overhead description

Maintenance signals

Workshop 4: Practical Design Exercises

Producing Aggregation Requirements from Access Demand Specification

Migration of SDH to OTN

Designing Aggregation Service

Designing Core Service

Module: 6. Signal Structures Up to 100 Gbit/s

Mapping of client signals

Concatenation

Mapping ODUk signals into the ODTUjk signal

Forward error correction using 16-byte interleaved RS (255,239) codecs

ODUk tandem connection monitoring (TCM) overhead

OPUk Multiplex Overhead

Basic signal structure,

ODTU12, ODTU13, ODTU23,

OPUk Multiplex Overhead,

OPUk Multiplex Structure Identifier (MSI)

OPU2 Multiplex Structure Identifier (MSI)

OPU3 Multiplex Structure Identifier (MSI)

OPUk Payload Structure Identifier Reserved overhead (RES)

ODU1 into ODU2 multiplexing

ODU2 into ODU3 multiplexing

ODU1 into ODU3 multiplexing

Automatic Protection Switching

Workshop 5: ROADM System

Module: 7. Testing Procedures for Installation and Design Validation

Optical System impairments

Optical Testing and Measurements

Reasons for Testing

Types of Test Measurements

Testing Guidelines

Error Ratios

Spectrum testing

Specifying Test & Troubleshooting Procedures

Module: 8. Management and Troubleshooting

G.874, Management aspects of the optical transport network element

G.874.1, Optical transport network (OTN) protocol neutral management information model for the network element view

G.875, Optical transport network (OTN) management information model for the network element view

Service using 10G Ethernet and 100G Ethernet

Module: 9. Review and Evaluation

Delivery Method

Instructor-Led with numerous exercises throughout.

Equipment Requirements

(This apply's to our hands-on courses only)

BTS always provides equipment to have a very successful Hands-On course. BTS also encourages all attendees to bring

their own equipment to the course. This will provide attendees the opportunity to incorporate their own gear into the labs and gain valuable training using their specific equipment.

Course Length

5 Days