Hands-On

Digital TV Systems Switchover

Digital TV Systems and Next Generation Networks

Course Description

This Training Series provides a modular program of training to be run over a period of 10 days. The aim is to provide 1 day and 2 day modules of training aimed at providing a fast overview for engineers and manager new to the subject of Digital Television and Next Generation Communications systems. It is intended that the modules will stand on their own so that participants can select those modules most appropriate to their need and not necessarily attend every module.

These modules examine the delivery of TV and communications over Next Generation Networks based upon IP core communications and optical carrier Ethernet services. The intention is to produce a Program suitable for participant with no prior knowledge to access the training and to build up a knowledge base quickly so that they can be valuable members of new and evolving digital TV and Media teams.

Module 1, will examine how and why digital television is sweeping the world very quickly. It will consider the way in which Analogue TV has been delivered in the past and how the digital dividend can provide increased government revenue by adopting digital TV. It will examine bandwidth issues and demonstrate using hands-on exercises different methods of encoding and of deliver without going into the technical details. At the end of this module attendees will be aware of what is possible and what the limits of technology are but not necessarily how thins work, which will be covered by later modules.

Module 2, identifies how digital TV is encoded in detail. It examines how MPEG-2 works and provides hands-on exercises experimenting with MPEG-2 rates and profiles. It then goes on to look and higher compression techniques of MPEG-4 and H.264 for encoding HDTV. At the end of this module participants will have a solid understand of how encoding works to a level that enables them to recognize the difference between MPEG-2 and H.264. To describe the difference between H.264 and Microsoft Windows Media Video 9 and to trancode between different codecs using free or open source software.

Module 3, examines multiplexing as it is used in Digital Video Broadcast systems. The DVB standards have been written to enable the same multiplexing techniques to be used for Terrestrial, Satellite and Cable delivery. A simplified subset is also used for delivery of IPTV using DVB-IPI. This module will teach students how DVB multiplexing works at both the Program stream and the Transport stream levels. It will introduce hands-on exercises to enable participants to capture transport streams and to analyze them to understand how multiple TV channels are multiplexed into a single high speed digital stream for broadcast. They will further study the service information and control tables used to allow set top boxes to navigate through the multiplexes, locate individual program streams and play them.

Module 4, considers how the Intellectual Property value of TV can be protected. The key to the success of any Television Services is high quality content that the viewer wishes to watch. This generally costs a lot of money and time to produce and so Intellectual Property owners like movie companies and commercial TV production companies need to prevent their content being pirated. Simulcrypt and Multicrypt provide standardized methods for Conditional Access that allow broadcasters to ensure the protection of high value content from illegal copying, and to restrict viewing to particular population groups where required. This is usually used for ensure the customer pays for pay-per-view or premium-rate channels. However it can also be used to restrict access to special channels used for security monitoring or Program production in special cases. More recent developments have allowed the delivery of video on demand over IP networks as well as recoding broadcast channels and the copying and retention of this material can be restricted by Digital Rights Management. This module will examine how DRM systems work and examine both commercial and open source systems.

Module 5, will consider Next Generation Networks and the evolution to packet based core networks from earlier generations of circuit based services. The module will look in fast overview at how earlier generation services can be emulated over high

speed IP cores to deliver service networks which can delver better performance at much lower cost yet higher reliability. It will also demonstrate the feasibility of this using hands-on exercises that integrate Voice, Internet Access and Television over the same Ethernet interface both wired and wireless.

Module 6, continues the examination of Next Generation Evolution but from the perspective of Carrier Transport Networks. In any modern Digital TV Broadcasting system it is necessary to transport the digital multiplexes from the TV Head-End to individual transmitter sites for broadcast. With Single Frequency Networks accurate timing and synchronization is also vital. This module will examine the options for these transport networks including Optical Fiber, microwave and satellite delivery. Technologies such as Ethernet Aggregation and protection switching will be considered to provide an understanding of how reliability can be controlled and improved.

Having introduced all the key building block technologies, Module 7 will provide an understanding of design. It will introduce the concepts of network design and using an example of a TV broadcasting Network demonstrate how the project can be take through the key stages from Initial Service Requirements definitions, Technical Specification, Service sizing, Wavelength allocation and planning, Transmitter sitting, installation, testing and delivery.

Module 8, will look at TV Program Production to give engineers an appreciation of the tools and techniques available for the artistic aspects of Program products, the technical aspects of editing, recording and mixing services and finally the storage and delivery. Using simple editing tools attendees will shoot some video, edit it and produce a short Program clip. They will then stream this over a network.

Module 9, Multicast IP Television is now used to deliver Television services in some administration as well as to provide interconnection between encoders and multiplexers within DVB Head-ends. This module provides an understanding of how IPTV streams are carried over RTP/UDP/IP, the difference between using TCP and UDP to deliver services and how to analyze these services using protocol Analyzers

Module 10 Configuring Routers and Switches for Multicast and Reliable carrier Services. This module will teach attendees how to configure elementary routing protocols, OSPF, Ethernet Aggregation and Protocol Independent Multicast on Cisco switches. Attendees will work as a group and configure individual interfaces to use specific VLANs, configure and test OSPF routing and them implement PIM for multicasting. They will then undertake hands-on exercise to demonstrate the correct working using IPTV streams.

Module 11 Service sizing and performance requires an understanding of simple statistics and applying this to broadcasting and transport network design. This module aims to help attendees understand why networks are never as fast as they expect and why projects always take linger then you expect. Providing an understanding of confidence intervals, elementary queuing theory and applying this to the design of network traffic allows attendees to better calculate the service profiles for real services and to apply their newly learned techniques to estimating service demands in the future.

Students Will Learn

- **Digital Television**
- **Digital Video Encoding**
- **MPEG-2 Transport Streams**
- **Content Protection Systems**
- **Next Generation Networks**
- **Carrier Ethernet Transport**
- **TV Program Production**
- **Multicast IP Television**
- **Router and Switch Configuration**
- **Network Sizing and Availability Calculation**

Target Audience

Anyone planning or working with Analog to Digital Switchover for Digital TV Systems and Next Generation Networks For Digital Switchover.

Prerequisites

Basic telecommunications and basic television broadcasting.

Course Outline

Module 1 Digital Television Overview 1 day
This module will examine how and why digital television is sweeping the world very quickly. It will consider the way in which Analogue TV has been delivered in the past and how the digital dividend can provide increased government revenue by adopting digital TV. It will examine bandwidth issues and demonstrate using hands-on exercises different methods of encoding and of deliver without going into the technical details. At the end of this module attendees will be aware of what is possible and what the limits of technology are but not necessarily how thins work, which will be covered by later modules.

1: Digital Television Architecture and Evolution
Colour Television

Evolution from Analogue: NTSC, PAL, SECAM

Digital Video Broadcasting

Formats and Signals

Bandwidths and Channels

Revenues from spectrum and services

2: Digitally-Compressed Television

Digital Modulation

MPEG Hierarchy, MPEG1, MPEG2, MPEG 4, H.264

Hands-on Demo of IPTV in class using MPEG-1 and MPEG-2

Digital Over-the-air Video Broadcasting

Comparison of ATSC Standards with ETSI DVB standards

Potential bandwidth reductions

Signal Power implications

Transmitter and receiver implications

3: TV Distribution Systems

Terrestrial UHF/VHF Broadcast Delivery

Alternatives

- Satellite Television Delivery
- Cable Television Delivery
- IPTV Deliver

From head-end to viewer

Back-Channel

Set-top Box Issues

Next Generation Media Players

Integration of DVB-T/DVB-T2 and IPTV Service Features

Module 2 Digital Video Encoding 1 Day

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and Microsoft Windows Media Video 9 and to trancode between different codecs using free or open source software.

1: MPEG Encoding
Video Formats: SDTV and HDTV

Evolution of MPEG

MPEG-2 and its parts

Source Encoding

MPEG Compression Concepts

Prediction and Interpolation

Ordering of pictures and blocks

Motion: Prediction, estimation and compensation

I, P and B Pictures

MPEG Levels and Profiles

Audio Compression

Framing Formats

Multiplexing of Signals

Hands-on Exercise encoding content with MPEG-2

2: MPEG-4 and H.264 Standards
Related standards: JPEG and JPEG2000

Video Objects (VO) and Video Object Plane (VOP)

I-VOP, P-VOP, B-VOP

Advanced Coding Efficiency (ACE)

Advanced Audio Coding (AAC)

Dolby Digital (AC3)

- Audio Codec 3, Advanced Codec 3, Acoustic Coder 3
- ATSC A/52

Texture Coding

Studio Quality Encoding

Evolution of MPEG4 Part 10 and H.264

AVC, H.26L, H.264 and other names

Hands-on exercise Trancoding MPEG-2 to H.264 and comparing result

Macro Prediction

Intra Prediction

Luma, Chroma and Signalling prediction

Deblocking Filter

Transform Quantization

Reordering

Entropy Coding

Deblocking Filter

Main Profiles

Context-based Adaptive Binary Arithmetic Coding (CABAC)

Extended Profiles

MPEG-2/MPEG-4/H.264 Comparisons Hands-on exercise Encoding/Transcoding HDTV
Module 3 MPEG-2 Transport Streams 1 Day

Module 3 examines multiplexing as it is used in Digital Video Broadcast systems. The DVB standards have been written to enable the same multiplexing techniques to be used for Terrestrial, Satellite and Cable delivery. A simplified subset is also used for delivery of IPTV using DVB-IPI. This module will teach students how DVB multiplexing works at both the Program stream and the Transport stream levels. It will introduce hands-on exercises to enable participants to capture transport streams and to analyze them to understand how multiple TV channels are multiplexed into a single high speed digital stream for broadcast. They will further study the service information and control tables used to allow set top boxes to navigate through the multiplexes, locate individual program streams and play them.

1: MPEG-2 Transport Streams and Packets
How MPEG-2 transport stream relate to MPEG-2 Encoding

MPEG-2 part 9

Transport stream format

MPEG Packets and headers

Hands-on exercise Analyzing a DVB-T transport Stream

Packetised Element Stream(PES)

PIDs and their combination in Programs

Service Information (SI)

Program Specific Information (PSI)
Program Allocation Table (PAT)

Program Map Table (PMT)

Clocking within Transport Streams

Decode Time Stamp (DTS)

Presentation Time Stamp (PTS)

System Clock Reference (SCR)

Hands-on Exercise identifying Streams and Clocking

Quantization of Program and Transport Streams

NIT, SDT & EITs: Effect on STB Behaviour

Channel Coding and Forward Error Recovery

Energy Dispersal

Reed-Solomon Coding

Convolutional Coding

Interleaving

Trellis Decoding
Temporal Spreading

Hands-on Exercise Analysing a transport stream to extract video and sound

Hands-on Exercise Analysing an HD Transport Multiplex

Module 4 Introduction to Content Protection Systems 1 Day

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1: Content Protection

The need for protection

Revenue models

Methods of pirating content

Cryptographic countermeasures

Block ciphers and stream ciphers

2. DVB Conditional Access

Conditional Access Table (CAT)

Conditional Access Mechanisms

CA Standards

- DVB-CSA
- Simulcrypt & Interoperability
- Common Interface

Encryption

Entitlement Management Messages (EMM)

Entitlement Control Messages (ECM)

Encoding ECM and EMM into the transport stream

Frequency of Key Changing
Subscriber Management Systems (SMS)

3: Customer Interface Issues: Set-top Boxes
Analog Video Reception

Digital Video Reception

Consumer Electronics Interface

Equipment Compatibility

Networking Interfaces

Decoding Mechanisms

Personal Video Recording Interfaces

In-Home Networking

Protected and Conditional Access Key interfaces

4: Digital Rights Management and Advance Protection Tools

Protected Broadcast Driver Architecture

Digital Rights Management

Example DRM Systems: Microsoft, ODA, Marlin

Watermarking

Examples of DRM in practice

Module 5 Next Generation Networks 1 Day

Module 5 will consider Next Generation Networks and the evolution to packet based core networks from earlier generations of circuit based services. The module will look in fast overview at how earlier generation services can be emulated over high speed IP cores to deliver service networks which can delver better performance at much lower cost yet higher reliability. It will also demonstrate the feasibility of this using hands-on exercises that integrate Voice, Internet Access and Television over the same Ethernet interface both wired and wireless.

1: Next Generation Network Technology Motivations for Next Generation Networks
Circuit Switched and Packet Switched Compared

Service Efficiency Considerations

Converged Cores

Internet Protocol (IP) Delivery Internet delivery options Integrating services for customer access Triple Play Hands-on exercise of Integrated TV and Voice network in classroom 2: Next Generation TV Delivery Digital delivery Studio to distributor delivery IP Delivery mechanisms Unicast vs Multicast Multicasting Addressing and Protocol Issues PIM and

IGMP Quality of Service Issues MPLS 21st Century Network Implications Triple Play Network Engineering Video on Demand

Web TV

Internet TV Portal Hands-on Exercise Using Video on Demand and Internet TV

Module 6 Carrier Ethernet Transport 2 Days

Module 6 continues the examination of Next Generation Evolution but from the perspective of Carrier Transport Networks. In any modern Digital TV Broadcasting system it is necessary to transport the digital multiplexes from the TV Head-End to individual transmitter sites for broadcast. With Single Frequency Networks accurate timing and synchronization is also vital. This module will examine the options for these transport networks including Optical Fiber, microwave and satellite delivery. Technologies such as Ethernet Aggregation and protection switching will be considered to provide an understanding of how reliability can be controlled and improved.

1: Carrier Ethernet Primer

Ethernet Speed Evolution to 10Gbit/s and beyond

How Ethernet Evolved

Evolution from 10 Mbit/s LAN to Gigabit Ethernet

Impact of Optical transmission

Removing the distance limitations

Ethernet switching

Bridging functions

Learning Bridges

Removing Loops

802.1d Spanning Tree and Rapid Spanning Tree

Ethernet Addressing

Address characteristics

Routability of address structures

Problems with MAC address Tables

How MAC addresses are used

ARP and IP

Limiting MAC address table sizes

Mac-in-Mac solutions

Multicasting

IGMP

Multicasting over Ethernet

Mechanisms for signalling Ethernet characteristics

GARP and GMRP

Tag Headers

IEEE802.1Q VLANs

GVRP

Overcoming the VLAN limit

Using VLANs within customer environments

VLANs in Carrier Environments

Service Separation

Impacts on Security

What limits the number of VLANs

Scaling Services

Q-in-Q solutions

Provider Layer 2 VPN Solutions Options

Provider Backbone Bridging

IEEE 802.1ad

Delivering Provider Backbone Transport

IEEE 802.1ah

2: Delivering Quality of Service in Carrier Environments

QoS Motivations

Analysing What Identifies QoS

Bandwidth

Delay

Delay variation

Availability

Access to Service Features

Delivering Bandwidth and Delay

Understanding Queues

Sizing for Service quality

QoS Signalling

Exploiting Tag Headers for QoS

Mapping QoS across the Transport network

IEEE802.1P/Q

Layer 2 vs Layer 3 QoS

Differentiated Services

3: Aggregation and Protection

Understanding Reliability and Availability

MTTF and MTTR

Calculating Availability

Impact of Redundancy

Independence of Services

Mechanisms for Improving Reliability

Topology considerations

Mesh

Ring

Trees

Ethernet Rapid Packet Ring (RPR)

Ring Resilience protocol (RRP)

Comparing Layers 1, 2 and 3 protection

Physical switching

Layer 2 switching

Layer 3 rerouting

Ethernet Aggregation

802.3ad Aggregation and Bridging

Aggregation groups

Aggregation for bandwidth improvement

Protection using Aggregated Services

Example aggregation network applications

IPTV service protection

Aggregation for bandwidth increase

Ethernet Rings

Delivering reliability for Service Level Agreements

4: MPLS Primer

Delivering High Performance Core Services

The Key Core Objectives

Scaling the problems of routing

Routing vs switching in the core

Cache Sizes

Label switching concepts

What is a label?

Normal hop-by-hop routing

Creation of Labels

Distribution of Labels

Function of Label switching

Forward Equivalence Class (FEC)

Label Edge Switches

Label Distribution Protocol

Explicit routed Label Switched Paths

Constraint routed Label Switched Paths

Traffic Engineering

Fast Rerouting

Module 7 Broadcast Network Design : 2 Days
Having introduced all the key building block technologies, Module 7 will provide an understanding of design. It will introduce the concepts of network design and using an example of a TV broadcasting Network demonstrate how the project can be take through the key stages from Initial Service Requirements definitions, Technical Specification, Service sizing, Wavelength allocation and planning, Transmitter sitting, installation, testing and delivery.

1. Broadcast Network Design Process

Transmission media: Microwave Radio vs Fiber Optics

Identifying the TV User Requirements

Documenting and Agreeing the User Specification

Translating into Technical Requirements

Specifying Key Network Parameters

Producing a Link Specification

Proving the Design Meets the Specification

Installing, Testing and Troubleshooting Procedures

Delivering Documentation of the Service

2. The Requirements Specification

Analyzing the User Requirements

Bit rate and bandwidth

Error ratio and availability

Locating where the service is required

Predicting the future needs

Documenting the Specification

3 Translating Requirements into Technical Specifications

Operational System Parameters

Fiber Optics Design Principles

Optical Sources: LED, Vertical Surface Emitting Lasers (VCSELs),Lasers

Modulation

Fiber Types: Multimode, Restricted Mode Launch Bandwidth, Laser Optimized Multimode, Single-mode

Deploying Wavelength Division multiplexing and Switching options

Hardware Selection Factors

Connectors and Splicing Options

Microwave Design Principles

Antennas

Detectors

Ground segments

4. Calculating Key Design Parameters

Theory And Principles Link Budgets

Cable Construction

Recommended Cable Types

Cable Selection

Termination Methods

5. Selecting the Right Technology Solutions

Availability and reliability

Physical and Logical Network Topologies

Network Management

6. Testing Procedures for Installation and Design Validation

Optical Testing and Measurements

Microwave Testing

Reasons for Testing

Types of Test Measurements

Testing Guidelines

Error Ratios

Spectrum testing

Specifying Test & Troubleshooting Procedures

7. Conformance and Delivery

Verifying the Design

Validating the Service

Proving the Delivered Network matches the Specification

Module 8 TV Program Production An Overview : 1 day

Module 8 will look at TV Program Production to give engineers an appreciation of the tools and techniques available for the artistic aspects of Program products, the technical aspects of editing, recording and mixing services and finally the storage and delivery. Using simple editing tools attendees will shoot some video, edit it and produce a short Program clip. They will then stream this over a network.

1. **IPTV Content Encoding and Control systems** Program Editing and Distribution

Video Editors

Camera Transfer

Functions of content editors Advertisement insertion

2. Production Planning

Scripting

Story Boards

Library Content

Dubbing and Sound engineering

Hands-on Content Construction Using content editing software the class will build a TV program from video fragments and then construct TV schedules with advertisement insertions to form local TV channels
Module 9 Multicast IP Television : 1 Day

Module 9 Multicast IP Television is now used to deliver Television services in some administration as well as to provide interconnection between encoders and multiplexers within DVB Head-ends. This module provides an understanding of how IPTV streams are carried over RTP/UDP/IP, the difference between using TCP and UDP to deliver services and how to analyse these services using protocol Analyzers

1.**Multicasting**

Deploying Multicasting for network delivery of video

Multicast routing approaches

Multicast extensions to Routing protocols

IGMP

Hands-on Exercise receiving Multicast IPTV

2. Encoders and Streamers

Transcoding

Hands-on Exercise Transcoding and stream Multicast TV

3. Protocol Independent Multicast (PIM)

Selecting Mode of operation: Dense or Sparse

Protocol exchanges to build tree

Protocol exchanges to prune tree

Potential failures and fixes

Hands-on Exercise Analyzing Multicast Streams using Protocol Analyzers

Module 10 Introduction to Router and Switch Configuration: 2 days

Module 10 Configuring Routers and Switches for Multicast and Reliable carrier Services. This module will teach attendees how to configure elementary routing protocols, OSPF, Ethernet Aggregation and Protocol Independent Multicast on Cisco switches. Attendees will work as a group and configure individual interfaces to use specific VLANs, configure and test OSPF routing and them implement PIM for multicasting. They will then undertake hands-on exercise to demonstrate the correct working using IPTV streams.

1: Cisco Routers and Switches

Architecture of Cisco Switches

Configuring Interfaces

Layer 3 Interfaces

Layer 2 Interfaces

Simple VLANs

Configuring IP Address

Hands-on Exercise configuring User Interfaces and Trunk Interfaces

2: Configuring Routing Protocols

Static Routes

OSPF

IGMP

PIM

Hands-on Exercise Configuring PIM

3: Aggregation

Port Channels

Assigning Layer 2 ports to port channels

IEEE 802.1Q

Link Aggregation Control Protocol

Hands-on Configuring Link Aggregation

4: Reliability Protocols

Importance of default routers

Loss of router access

Using HSRP or VRRP to build reliable networks

Hands-on Configuration and testing of Resilient Network

Running TV through multi switch network and validation automatic switch over on link and switch failure.

Module 11 Network Sizing and Availability Calculation 1 Day

Module 11 Service sizing and performance requires an understanding of simple statistics and applying this to broadcasting and transport network design. This module aims to help attendees understand why networks are never as fast as they expect and why projects always take linger then you expect. Providing an understanding of confidence intervals, elementary queuing theory and applying this to the design of network traffic allows attendees to better calculate the service profiles for real services and to apply their newly learned techniques to estimating service demands in the future.

1: Sizing and Performance Analysis

Capacity Considerations:

Delivery Method

Instructor-Led with numerous Hands-On labs and exercises.

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

10 Days