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**Flexibility**: We offer a variety of training options including onsite, virtual, self-paced eLearning, and public training events

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Curriculum

We help our customers tackle technology, faster.

Curriculums include:

- **SELF-PACED**
  - Self-study, on-demand courses
  - 100% online and available 24/7

- **EXPERT-LED LIVE**
  - Live, expert-led
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  - Self-study, plus live, expert-led sessions to reinforce learning
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- 5G and IoT
- Automation and Insights
- LTE and VoLTE
- IP and Ethernet
- Network Virtualization
5G and IoT
5G and IoT

We help our customers tackle technology, faster.

Curriculums include:

5G and IoT
Automation and Insights
LTE and VoLTE
IP and Ethernet
Network Virtualization

SELF-PACED
Welcome to 5G
5G NR Air Interface Overview - Part I
5G NR Air Interface Overview - Part II
5G Core Network Overview

BLENDeded
5G (SA) RAN Signaling and Operations
Introduction to 5G
5G (NSA) RAN Signaling and Operations
5G (NSA) RAN Performance Workshop: Part I
5G Core Network Signaling and Operations

EXPERT-LED LIVE
5G Services and Network Architecture
5G Radio Technologies and Deployments
VRAN and Open RAN Overview
Dark Fiber and Ethernet Backhaul
LTE and NB-IoT
Multi-Access-Edge Computing (MEC)
Network Slicing in 5G
5G for Business
5G Essentials
5G Networks and Services
5G NR Air Interface
5G RF Planning and Design
MEC Architecture and Operations Overview
5G Voice Solutions – VoNR and EPS Fallback
LTE-M and NB-IoT Signaling and Operations
Welcome to 5G

5G promises to enable a wide variety of new wireless communications services and capabilities, ranging from high-speed, high-capacity broadband access to extremely reliable low-latency communications to machine-type communications on a massive scale. To deliver on these promises, everything about the wireless network must change, including the devices, the radio interface, the radio access network (RAN), and the core network. This self-paced eLearning course is for both technical and non-technical students, offering a high-level end-to-end overview of 5G networks. It explores use cases for different verticals, 5G network architecture, 5G device types, 5G air interface including the use of mmW spectrum and massive MIMO, and deployment scenarios.

Intended Audience
This course provides an end-to-end overview of 5G networks and is targeted for a broad audience - both technical and non-technical. This includes those in sales, marketing, deployment, operations, and support groups.

Objectives
After completing this course, the student will be able to:

1. Identify the motivations and goals for 5G networks
2. Sketch the end-to-end architecture of a 5G network
3. Describe the types of devices supported in 5G networks
4. Summarize the basic concepts of 5G air interface while using various spectrum bands
5. Sketch the high-level architectures of the 5G NG-RAN and 5GC/NGC
6. List various services being supported in 5G networks
7. Illustrate the deployment and interworking solutions for 5G

What You Can Expect
1. Self-Paced Duration: 1 HOUR

Outline
1. Motivations for 5G
   1.1 5G use cases
   1.2 eMBB
   1.3 URLLC
   1.4 mMTC
   1.5 5G goals and targets
   1.6 5G building blocks
2. 5G Devices
   2.1 Multiplicity of devices
   2.2 IoT devices and non-IoT devices
   2.3 Device capabilities
3. 5G Network Architecture Overview
   3.1 5G architecture goals
   3.2 5G network components
   3.3 5G NG-RAN
   3.4 5G core network
   3.5 Network slicing
   3.6 MEC
4. 5G NR Air Interface
   4.1 Variety of spectrum bands for 5G
   4.2 Massive antennas for mmW
   4.3 Reuse of OFDM/OFDMA concepts
   4.4 Flexible OFDM numerologies
   4.5 Flexible frame and slot structure
5. 5G NG-RAN
   5.1 Split architecture
   5.2 gNB-CU and gNB-DU
   5.3 Transport network
6. 5G Core Network
   6.1 5G Core Network functions
   6.2 Control and User Plane separation
   6.3 Service-based architecture
7. 5G Deployment
   7.1 NSA and SA deployment options
   7.2 Interworking with 4G LTE
   7.3 Deployment considerations
   7.4 Putting It All Together

View Curriculum
5G promises to enable a variety of new services, ranging from high-speed, high-capacity broadband access to ultra reliable low-latency communications to massive machine-type communications. To deliver on these promises, the wireless network must change, including the devices, the radio interface, the radio access network (RAN), and the core network. Part I of this self-paced course offers a high-level technical overview of 5G NR (New Radio) air interface – its features, the use of low-mid-high band spectrum, the reuse of the principles of OFDM/OFDMA, and the use of massive antennas for beamforming and MIMO. Part II covers the flexible numerologies, channels and frame/slot structure, and steps through the life of a 5G UE. Part II concludes with how the technologies and standards converge to meet the performance goals set for 5G.

Intended Audience
This course is designed for a broad audience of wireless network engineers. This includes those in RF, RAN planning, engineering, operations, troubleshooting and support groups.

Objectives
After completing this course, the student will be able to:
■ List the performance goals of the 5G network
■ Compare the different 5G frequency spectrums and their characteristics
■ Describe MIMO and the beamforming techniques used in 5G
■ List the key features of the 5G NR air interface
■ Sketch the flexible frame and slot structure of 5G NR

What You Can Expect
■ Self-Paced Duration: 1 HOUR

Outline
1. 5G Scenarios and Performance Goals
   1.1 Higher data rates
   1.2 Lower latency
   1.3 Higher connection density
2. 5G NR Air Interface Overview
   2.1 Key features of 5G air interface
   2.2 Flexible numerologies
   2.3 Air interface protocol stack
3. Frequency Spectrum for 5G
   3.1 Spectrum considerations
   3.2 Low, mid, and high bands
   3.3 Channel bandwidths
   3.4 Radio signal propagation
4. MIMO and Beamforming
   4.1 Massive antenna
   4.2 Beamforming and beam tracking
5. Protocol Stack Enhancements
6. 5G Operating Bandwidth
7. 5G NR Frame and Slot Structure
   7.1 Flexible sub-carrier spacing
   7.2 Flexible frame and slot structure
   7.3 Carrier bandwidth part
   7.4 Numerology

View Curriculum
5G NR Air Interface Overview - Part II

5G promises to enable a variety of new services, ranging from high-speed, high-capacity broadband access to ultra reliable low-latency communications to massive machine-type communications. To deliver on these promises, the wireless network must change, including the devices, the radio interface, the radio access network (RAN), and the core network. Part I of this self-paced course offers a high-level technical overview of 5G NR (New Radio) air interface – its features, the use of low-mid-high band spectrum, the reuse of the principles of OFDM/OFDMA, and the use of massive antennas for beamforming and MIMO. Part II covers the flexible numerologies, channels and frame/slot structure, and steps through the life of a 5G UE. Part II concludes with how the technologies and standards converge to meet the performance goals set for 5G.

Intended Audience
This course is designed for a broad audience of wireless network engineers. This includes those in RF, RAN planning, engineering, operations, troubleshooting and support groups.

Objectives
After completing this course, the student will be able to:
- Identify key channels and their usage in the downlink and uplink
- Step through the life of a 5G UE at a high level in non-standalone architecture
- Step through the life of a 5G UE at a high level in standalone architecture
- Identify ways in which 5G NR meets the performance goals of 5G

What You Can Expect
- Self-Paced Duration: 1 HOUR

Outline
1. Key Signals and Channels of 5G NR
   1.1 Downlink signals and channels
   1.2 Uplink signals and channels
2. Life of a 5G UE
   2.1 NSA vs. SA operations
   2.2 Non-Standalone operations
   2.3 Network acquisition
   2.4 Attach
   2.5 Data transfer
   2.6 Standalone Operations
   2.7 Network acquisition
   2.8 Registration
   2.9 PDU session setup
   2.10 Data transfer
3. Meeting 5G Performance Goals
   3.1 Ways to achieve higher data rates
   3.2 Ways to achieve lower latency
   3.3 Ways to achieve higher connection density
   3.4 Putting It All Together
5G promises to enable a wide variety of new wireless communications services and capabilities, ranging from high-speed, high-capacity broadband access to extremely reliable low-latency communications to machine-type communications on a massive scale. To deliver on these promises, everything about the wireless network must change, including the devices, the radio interface, the radio access network (RAN), and the core network. This course focuses on the principles of the 5G core network, its connectivity to the radio network and interworking with the 4G EPC. Topics such as Service-Based Architecture (SBA), PDU Session Establishment, Network Slicing and Multi-Access Edge Computing (MEC) as they relate to 5G are described.

Intended Audience
This course is designed for a broad audience of wireless network engineers. This includes those in network planning, engineering, operations, troubleshooting and support groups.

Objectives
After completing this course, the student will be able to:
- List the key principles behind the evolving 5G core network
- Sketch the 5G core network, its connectivity to the radio network and interworking with the 4G EPC
- Describe the purpose behind Service-Based Architecture (SBA)
- Describe the QoS framework of 5G and compare it with 4G
- Step through the network operations of registration and PDU session establishment
- Describe network slicing and how it is used in 5G
- Describe MEC and how it can be used in 5G

What You Can Expect
- Self-Paced Duration: 1 HOUR

Outline
1. Principles of the 5G Core Network
   1.1 Control and User Plane separation
   1.2 Modularization
   1.3 Virtualization
   1.4 Service-based Architecture
   1.5 Network Slicing
2. 5G Core Network Architecture
   2.1 Key network functions and their roles
   2.2 Network connectivity
   2.3 Interworking with 4G EPC
3. Service-Based Architecture
   3.1 Network interfaces and services
   3.2 Network Exposure Function
   3.3 Protocols
4. Multi-Access Edge Computing (MEC)
   4.1 Defining MEC
   4.2 Need for MEC
   4.3 MEC in action in 5G network
5. Network Slicing
   5.1 Defining network slicing
   5.2 Need for network slicing
   5.3 Network Slice Selection Function
   5.4 Network slicing in action
6. Network Operation: Registration of UE
   6.1 Authentication
   6.2 Security framework
   6.3 UE states
7. QoS Framework in 5G
   7.1 QoS flow
   7.2 Roles of 5QI and QFI
   7.3 QoS mapping with 4G
8. PDU Session Establishment
   8.1 Components of PDU session
   8.2 IP and Ethernet addressing
   8.3 Putting It All Together
Technology Primer: 5G Services and Network Architecture

ITU is defining 5G standards as part of IMT2020 with active input from industry groups like the NGMN alliance and 3GPP. This course is an overview of target services and potential technologies of the network architecture in the upcoming 5G standards. Starting with the 5G services and performance targets, the 5G network architecture and building blocks are explored. Then, the evolution of the 5G RAN is discussed. An overview of key components for a 5G wireless network is given and fundamental technologies for a 5G network architecture are then discussed. Afterwards, potential deployment and evolution scenarios are summarized. Finally, RAN and core technologies converge with the exploration of network slicing and Mobile Edge Computing (MEC).

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations.

Objectives
After completing this course, the student will be able to:
- Give examples of 5G use case families and identify related performance targets for 5G networks
- Highlight the key building blocks of 5G that help achieve higher data rates and lower latency
- Sketch the end-to-end 5G network architecture, including 5G NG-RAN and 5G Core (5GC)
- Step through the deployment options of 5G
- Define network slicing and identify its benefits in 5G networks
- Define MEC and identify its benefits in 5G networks

What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: LTE Overview (eLearning)

Outline

1. 5G Services and Performance Targets
   1.1 eMBB, mMTC, URLLC Use Cases
   1.2 5G Specifications Status

2. 5G Architecture Building Blocks
   2.1 Architecture Principles and Key Features
   2.2 5G Spectrum

3. Evolution to 5G NG-RAN
   3.1 gNB Split Architecture
   3.2 Deployment Scenarios

4. 5G Core Network Architecture and Operations
   4.1 5G Core Architecture
   4.2 Life of 5G UE

5. 5G Network Deployments
   5.1 Non-Standalone (NSA) Deployment
   5.2 Standalone (SA) Deployment

6. Network Slicing in 5G
   6.1 Network Slicing Examples

7. Multi-Access Edge Computing
   7.1 Benefits and Use Cases

View Curriculum
Technology Primer: 5G Radio Technologies and Deployments

3GPP is evaluating various technologies to determine specific elements of a 5G wireless network. These technologies enable the 5G wireless network to achieve the 5G performance goals defined by ITU as part of IMT2020 requirements. This course describes potential spectrum for 5G including millimeter wave spectrum. 5G RF Planning based on the new spectrum is covered. Furthermore, the course discusses enhancements to advanced antenna techniques such as massive MIMO are explained as well as the new frame structure being investigated by 3GPP. Finally, potential deployment and evolution scenarios are summarized.

Intended Audience

A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations

Objectives

After completing this course, the student will be able to:

■ Give examples of spectrum bands for 5G
■ Summarize RF propagation differences between sub-6 GHz signals and mmW signals
■ Explain how massive MIMO facilitates beamforming
■ List the key features of 5G NR including the air interface, frame structure, and related numerology
■ Sketch the 5G NG-RAN architecture
■ Illustrate potential 5G deployment scenarios

What You Can Expect

■ Expert-Led Live Duration: 4 HOUR
■ Prerequisite: LTE Overview (eLearning)
■ Prerequisite: Technology Primer: 5G Services and Network Architecture (Instructor Led)

Outline

1. 5G Spectrum
   1.1 Performance Targets
   1.2 Low, Mid, High Spectrum
2. 5G RF Planning Considerations
   2.1 Propagation Characteristics
   2.2 Inputs to RF Design
3. Massive MIMO and Beamforming
   3.1 Beamforming Techniques
   3.2 Full Dimension MIMO
4. 5G NR Frame Structure and Numerology
   4.1 Frame Structure Enhancements
   4.2 5G NR Parameter Relationships
5. 5G RAN Evolution
   5.1 gNB Split Architecture
   5.2 RAN Transport Connectivity
6. 5G Deployment Scenarios
   6.1 NSA and SA Deployment
   6.2 NSA Architecture

View Curriculum
Technology Primer: VRAN and Open RAN Overview

The virtualized RAN and Open RAN initiative of O-RAN Alliance are introduced into the 5G RAN to support 5G uses cases of mobile broadband, edge computing, and IoT. This training presents an overview of 5G RAN and gNB Split architecture, concepts of virtualization in RAN, role of RU, gNB-DU and gNB-CU and their connectivity of CPRI, eCPRI and Ethernet.

Intended Audience

This course is intended for planning, engineering, operations, and systems performance teams.

Objectives

After completing this course, the student will be able to:

- Sketch the network architecture of 5G RAN and understand the placement of RAN components
- Draw the connectivity of RAN components and identify the role of CPRI and Ethernet
- Highlight the benefits of virtualization in RAN and potential use cases of virtualization
- Sketch Option 7-2x interface defined by ORAN and identify its benefits

What You Can Expect

- Expert-Led Live Duration: 4 HOUR
- Prerequisite: Welcome to 5G (self-paced eLearning)

Outline

1. Virtualized RAN in 5G
   1.1 5G RAN Components - gNB-CU and gNB-DU
   1.2 Protocols and Interfaces
   1.3 Separation of User and Control Planes
   1.4 Virtualization in 5G RAN
   1.5 Fronthaul, Midhaul, and Backhaul
   1.6 Data rate and distance requirements
   1.7 Role of CPRI and Ethernet

2. Open RAN Architecture
   2.1 Separation of gNB-DU and Radio Unit (RU)
   2.2 O-RAN Option 7-2x interface
   2.3 Role of eCPRI
   2.4 Benefits of O-RAN architecture
   2.5 Connectivity of 5G RAN with 4G - X2
   2.6 Signaling and Traffic Paths
   2.7 Considerations for Sub 7 GHz and mmW

View Curriculum
Technology Primer: Dark Fiber and Ethernet Backhaul

Communication Service Providers around the globe continue to experience rapid growth in data traffic everyday. Deployment of Dark Fiber on the backhaul is a key step in providing the capacity and speeds to support this. This technical primer provides an overview of fiber technology and its use in the transport network.

Intended Audience
This course is an introductory course tailored to meet the needs of a wide range of audiences including project managers, real-estate, construction, engineering and operation team members.

Objectives
After completing this course, the student will be able to:

- Define backhaul and fronthaul transport networks that use single λ, CWDM and DWDM
- Define dark fiber and explain the benefits of using dark fiber in the transport networks
- Explain ROADMs in the context of optical transmission and optical switching
- List the hardware and optical devices used in the dark fiber networks
- Discuss testing procedures and Fiber Characterization Reports from vendors.

What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: Knowledge of backhaul architecture

Outline

1. Motivation
   1.1 Define dark fiber
   1.2 Explain the benefits of using dark fiber

2. Transport Networks
   2.1 Fronthaul vs. backhaul
   2.2 Fronthaul – Daisy chain, hub and spoke, rings
   2.3 Backhaul rings
   2.4 Single Lambda vs. WDM
   2.5 Wave Division Multiplexing
   2.6 Coarse Wavelength Division Multiplexing (CWDM) vs. Dense WDM (DWDM)

3. Physical Characteristics of Fiber
   3.1 Optical fiber device components
   3.2 Fiber optic spectrum
   3.3 Best practices for fiber handling

4. Dark Fiber Topology
   4.1 ROADMs
   4.2 O-E-O – Changing from WDM to Single λ
   4.3 Capacity
   4.4 Access and aggregation rings
   4.5 Optical devices and hardware

5. Switching and Redundancy
   5.1 VLAN steering
   5.2 BFD and switchovers

6. Testing and Fiber Characterization Reports
   6.1 OTDR
   6.2 CPRI testing
   6.3 Fiber characterization reports
Internet of Things (IoT) is expected to dominate the telecom market where machines exchange data for intelligent applications. Devices and networks supporting IoT pose unique challenges such as low power, low cost, low mobility, and long battery life. This course addresses several low power wide area (LPWA) network technologies defined by 3GPP to meet these requirements. 3GPP-defined LPWA technology options include LTE-M (or enhanced machine type communication) and Narrowband IoT (NB-IoT). This course provides a foundation for MTC and NB-LTE and their extensions. Fundamental concepts of IoT-centric optimizations for a wireless network are explained. IoT-specific characteristics of the wireless network and relevant UE categories (e.g., M1, M2, NB1, and NB2) are described.

Intended Audience
Technical and product marketing personnel working for wireless operators, equipment and device manufacturers, as well as IoT architects and designers.

Objectives
After completing this course, the student will be able to:
- Define IoT and give examples of LPWA technologies
- Explain how the requirements for cellular IoT are achieved in LTE-M and NB-IoT
- Describe the key features of the LTE-M and NB-IoT air interface
- Specify key characteristics of NB-IoT and LTE-M device categories
- Sketch the end-to-end 3GPP network architecture and data delivery methods for cellular IoT

What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: LTE Overview (eLearning)

Outline
1. **IoT: What and Why**
   1.1 What is the Internet of Things?
   1.2 Cellular IoT Growth and Applications
   1.3 The LPWA Landscape and Standardization of Cellular IoT

2. **Wireless Optimizations for IoT**
   2.1 Wireless Requirements of IoT
   2.2 Optimization of IoT Operations

3. **Capacity Management and Enhancements**
   3.1 Capacity Optimization
   3.2 Overload Control and Congestion
   3.3 Extended Access Barring
   3.4 Single Cell Point-to-Multipoint

4. **Coverage Enhancements**
   4.1 Repetitions for Improved Coverage
   4.2 Power Density and Coverage
   4.3 TX/RX Diversity and Frequency Hopping

5. **Battery Life Enhancements**
   5.1 Power Save Mode
   5.2 Extended DRX for Idle Mode
   5.3 Extended DRX for Connected Mode

6. **Device Positioning**
   6.1 E-Cell ID Method
   6.2 OTDOA for IoT

7. **Network and Device Enhancements for IoT**
   7.1 Attach and Data Delivery Options
   7.2 Network and Enhancements for IoT
   7.3 Data Delivery Options
   7.4 Security for IoT

8. **UE Categories for LTE-M and NB-IoT**
   8.1 Overview of Release 13 and 14 UEs
   8.2 UE Category M1
   8.3 UE Category NB1
   8.4 UE Category M2
   8.5 UE Category NB2

9. **LTE-M and NB-IoT Operations**
   9.1 Deployment Scenarios
   9.2 Radio Resources and Channels
   9.3 Downlink Traffic Processing
   9.4 Uplink Traffic Processing

10. **Additional Information**
    10.1 EC-GSM Key Features
    10.2 Unlicensed IoT Solutions

**View Curriculum**
Technology Primer: MEC

Multi-Access Edge Computing (MEC) pushes cloud computing capabilities closer to the user across multiple access network domains. This course provides an overview of MEC framework, underlying technology and its use cases. The course starts with the definition of MEC, its characteristics, benefits, and business drivers. The MEC architecture defined by ETSI is illustrated. The key components such as Mobile Edge Host (with platform, infrastructure, and applications) and MEC management are described. Technology enablers for MEC such as the cloud infrastructure, NFV, SDN, microservices, and 5G services are discussed. MEC location strategies are summarized. Implementation of MEC in a 5G network is also described. The course concludes with a discussion on challenges faced by MEC.

Intended Audience

A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks

Objectives

After completing this course, the student will be able to:
1. Define Multi-Access Edge Computing (MEC)
2. List the key use cases and benefits of MEC
3. Illustrate the ETSI reference architecture for MEC
4. Identify key technology enablers for MEC
5. Describe how MEC interacts with the rest of the 5G network

What You Can Expect

- Expert-Led Live Duration: 4 HOUR
- Prerequisite: 5G Core Network Overview (eLearning)
- Prerequisite: Technology Primer: 5G Services and Network Architecture

Outline

1. Edge Computing in Networks
   1.1 MEC: Definition
   1.2 MEC characteristics
   1.3 MEC benefits
   1.4 Business drivers
   1.5 Overview of MEC-facilitated use cases (e.g., video streaming and AR/VR)
   1.6 MEC standardization (e.g., ETSI and 3GPP)

2. MEC Architecture and Functions
   2.1 ETSI reference architecture
   2.2 Mobile Edge Host (platform, infrastructure, applications)
   2.3 MEC management (host-level, system level)

3. MEC Technology Enablers
   3.1 Cloud infrastructure
   3.2 Network Functions Virtualization (NFV)
   3.3 Software-Defined Networking
   3.4 Microservices
   3.5 Target 5G services

4. Deployment and Use Cases
   4.1 MEC server location strategies
   4.2 MEC in 5G (CAPIF, LADN, PDU Session)
   4.3 Challenges and key considerations
Technology Primer: Network Slicing in 5G

Network slicing is one of key components that provide logical virtual network slices to support diversified services like mobile broadband, massive IoT, and ultra-reliable low latency services by leveraging the technology of SDN and NFV. This course provides an overview of Network slicing across Core, RAN and Transport networks in 5G, its operation and deployment. The course also provides an insight into how Network slicing in 5G works better as compared to techniques used in 4G LTE.

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations

Objectives
After completing this course, the student will be able to:
- List examples of 5G usage scenarios and their unique needs
- Define a Network Slice and describe how slicing is applied across 5G networks
- Describe the limitations of Network slicing in 4G LTE networks
- Describe the procedures involved to operate a Network slice
- Explain the Life-cycle Management of Network slice

What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: Technology Primer: 5G Services and Architecture (Instructor Led)
- Prerequisite: 5G Core Network Overview (eLearning)

Outline
1. What and Why
   1.1 5G Usage Scenarios
   1.2 Needs of Service Provider
   1.3 What is Network slice?
   1.4 Network Slicing today and its limitations
   1.5 Network slicing in 5G
2. Network Slicing in 5G Networks
   2.1 Core network
   2.2 Transport network
   2.3 Radio Access network
   2.4 Cloud Infrastructure (Multi-Tenancy)
3. Network Slicing Operations
   3.1 Selection of Network slice by UE
   3.2 Registration
   3.3 Session establishment
4. Network Slicing Deployment
   4.1 Network Slice Management Framework
   4.2 Life Cycle Management
   4.3 Configuration Management
   4.4 Performance and Assurance

View Curriculum
Technology Primer: 5G - A Business Perspective

5G is generating a lot of discussion as the successor to 4G LTE. This primer looks carefully at 5G and provides a well-reasoned view of the technology and its potential. It brings a practical clarity to the question 'What is 5G?', defining 5G and covering important 5G terms and concepts. It helps participants explain why not all 5G is created equal, and explores the inherent flexibility built into the 5G specification. It also provides a perspective on the applications and monetization potential for this new technology.

Intended Audience
Those in business roles who need to speak accurately and confidently about 5G and its applications.

Objectives
After completing this course, the student will be able to:
- Concisely define 5G
- Describe three areas of flexibility designed into 5G
- Explain the benefits and challenges of deploying 5G in millimeter-wave and low-band spectrum
- Describe different approaches that operators will take in deploying 5G
- List and defend several key applications of 5G
- Describe the 5G landscape in terms of the ecosystem and major players

What You Can Expect
- Expert-Led Live Duration: 4 HOUR

Outline
1. 5G in a Nutshell
   1.1 5G: What and why
   1.2 5G performance targets
   1.3 5G flexibility: three key applications
   1.4 The 5G roadmap
   1.5 5G New Radio (NR)
2. 5G: The Radio Side
   2.1 5G, spectrum implications and millimeter wave spectrum
   2.2 Massive MIMO and beamforming
   2.3 5G: How fast?
   2.4 Low latency: How low, and who cares?
   2.5 Edge Computing and Multi-Access Edge Computing (MEC)
   2.6 What does ultra-reliable mean in 5G?
   2.7 5G: Separating hype from reality
3. 5G: The Network Side
   3.1 5G Non-Standalone (NSA) New Radio
   3.2 5G Standalone (SA) New Radio
   3.3 The virtualized core
   3.4 Network slicing
4. 5G Deployment Approaches
   4.1 5G for coverage
   4.2 5G for speed
   4.3 5G for fixed access
5. Monetizing 5G
   5.1 Applications enabled by 5G
   5.2 5G business models
   5.3 5G for fixed wireless
   5.4 5G for the enterprise
   5.5 5G and IoT
5G Essentials

5G is considered for deployment in various frequency bands with large amounts of bandwidth and massive MIMO – thus completely changing the ways wireless networks are designed, engineered, and deployed. 5G networks support network slicing creating new business opportunities to support new market segments and use cases such as massive IoT, connected cars, smart communities, mission critical applications, industry automation, etc. This course gives an overview of the 5G end-to-end network, its capabilities, and deployment scenarios. It helps you prepare for gradual deployment of 5G so you collaborate with various teams for effective network planning, design and engineering, and deployment.

Intended Audience

This course is intended for wide audiences in network planning, project management, network engineering, and operations.

Objectives

After completing this course, the student will be able to:

- Identify use cases and new opportunities of 5G
- Specify 5G performance targets and identify key enablers
- Sketch the evolving 5G NG-RAN architecture
- Identify the roles of backhaul, midhaul, and fronthaul transport
- Highlight the key features of 5G NR
- Identify the impact of mmW spectrum and massive MIMO
- Identify the scenarios of Non-Standalone (NSA), dual connectivity and Standalone (SA) deployment
- Sketch the 5G core network architecture and describe how it supports network slicing and MEC

What You Can Expect

- Expert-Led Live Duration: 8 HOUR
- Prerequisite: Understanding of LTE and LTE-Advanced capabilities
- Prerequisite: Understanding of core and transport networks

4. 5G NR NSA Deployment
   4.1 Non-standalone (NSA) Deployment
   4.2 Option – 3x with EPC
   4.3 Dual connectivity with LTE & 5G NR
   4.4 Bearer choices in Option 3x

5. 5G Core and SA Deployment
   5.1 5G Core Network architecture
   5.2 Network slicing in 5G
   5.3 Edge computing
   5.4 Migrating from NSA to SA
   5.5 Summary and take-aways
5G Networks and Services

This course takes an in-depth look at the end-to-end 5G network (5GC, NG-RAN, and transport) and related operations including NSA and SA deployment scenarios. It provides key features and functionalities of the 5G NR, split architecture of NG-RAN, transport network options, 5G core network architecture based on SBA, and comparison with 4G EPC. Complementary technologies of network slicing, MEC as well as automation and orchestration are covered. It gives an overview of 5G operations through the life of a 5G device. Finally, 5G deployment scenarios of NSA and SA are covered.

Intended Audience

This technical course is intended for planning, design, engineering and operations personnel who need to get an understanding of the 5G core and radio network architecture and operations.

Objectives

After completing this course, the student will be able to:

- Sketch 5G core (5GC) network architecture and identify network functions
- Sketch 5G RAN architecture and split architecture of gNB
- Describe various interfaces and related protocols of 5G end-to-end network
- Step through the life of a 5G device to understand key operations of 5G
- Identify technologies such as network slicing, edge computing, virtualization and orchestration
- Summarize the deployment status of 5G

What You Can Expect

- Expert-Led Live Duration: 16 HOUR
- Prerequisite: Technology Primer: 5G Services and Network Architecture (Instructor-led)
- Prerequisite: Technology Primer: 5G Radio Technologies and Deployments (Instructor-led)

Outline

1. 5G in a Nutshell
   1.1 5G Services and performance goals
   1.2 End-to-end 5G network architecture
   1.3 Deployment options

2. 5G RAN Architecture
   2.1 RAN evolution for 5G
   2.2 5G RAN architecture, interfaces, and protocols
   2.3 Cloud and Open RAN

3. 5G Core Network Architecture
   3.1 Core network architecture
   3.2 Network functions and interfaces
   3.3 PDU sessions
   3.4 QoS in 5G
   3.5 Edge computing support
   3.6 Service-Based Architecture (SBA)
   3.7 Security framework in 5G
   3.8 LTE and 5G Interworking

4. Life of a UE in 5G
   4.1 Power up operation
   4.2 Registration
   4.3 IP connectivity
   4.4 QoS in 5G
   4.5 Data transfer
   4.6 Mobility
   4.7 Security in 5G

5. Supporting Technologies
   5.1 Cloud and virtualization
   5.2 Automation and orchestration
   5.3 Network slicing
   5.4 Multi-access Edge Computing (MEC)

6. 5G Deployments
   6.1 4G to 5G migration
   6.2 NSA Option 3x Connectivity
   6.3 Split bearer options
   6.4 NSA call flows
5G NR Air Interface

This course takes an in-depth look at the 5G NR Air Interface, 5G NG-RAN architecture and key operations that enable a 5G network to support the target 5G services. Key features of 5G NR such as flexible frame structure, DL and UL channels and signals and their functions are described in detail. Registration and session setup are discussed along with a look at network slicing. The data transfer in both downlink and uplink is described. Mobility in connected, inactive, and idle modes is discussed.

Intended Audience
This detailed technical course is intended for planning, design, RAN operations and performance engineers and related job functions.

Objectives
After completing this course, the student will be able to:
- Illustrate the architecture of the NG-RAN
- Describe the frame structure with numerology of the air interface
- List downlink and uplink signals and channels and describe their function
- Identify key steps of network acquisition, random access, and connection setup
- List main steps of registration, network slice selection, and PDU session setup
- Give examples of QoS parameters in 5G
- Explain how data is transferred in the downlink and the uplink
- Differentiate between the connected mode mobility and the idle/inactive mode mobility

What You Can Expect
- Expert-Led Live Duration: 16 HOUR
- Prerequisite: Technology Primers: 5G Services and Network Architecture
- Prerequisite: Technology Primers: 5G Radio Technologies and Deployments

Outline
1. 5G in a Nutshell
   1.1 5G Services and performance goals
   1.2 Key 5G components
   1.3 NSA and SA deployments
2. NG-RAN Architecture
   2.1 5G network architecture
   2.2 Multi-RAT dual Connectivity (e.g., EN-DC)
   2.3 NG-RAN Interfaces and Protocols
   2.4 NG-RAN and UE identifiers
   2.5 Cloud RAN and Transport
3. New Radio (NR) Air Interface
   3.1 Numerology and frame structure
   3.2 Beamforming and MIMO
   3.3 Downlink Signals and Channels
   3.4 Uplink Signals and Channels
   3.5 NR Protocols and UE States
4. Network Access and Connection Setup
   4.1 Network Acquisition
   4.2 Random access procedure
   4.3 RRC Connection Setup
5. Registration and PDU Session Setup
   5.1 QoS framework in 5G
   5.2 Registration
   5.3 Network Slicing
   5.4 PDU Session setup
6. DL and UL Data Transfer
   6.1 Bearer setup in NSA Option 3x
   6.2 Frame and Slot structure in 5G NR
   6.3 Downlink data transfer
   6.4 Uplink data transfer
7. Mobility and Handovers
   7.1 Cell- and Beam-level mobility
   7.2 Connected Mode Mobility - Handovers
   7.3 Inter-DU/Intra-CU Handovers
   7.4 Handovers in NSA Option 3x
   7.5 Idle Mode mobility
   7.6 Paging and RNA Update

View Curriculum
5G RF Planning and Design

This course takes an in-depth look at the RF planning and design aspects of 5G. It summarizes the essentials of the 5G air interface. MIMO and beamforming in 5G and suitable propagation models are discussed. The link budgets for 5G for different scenarios are calculated and compared with the LTE link budget. The RF cell configuration and RF operational parameters are discussed. Finally, the overall process of the RF design for 5G is described including traffic mapping and propagation modeling. The use of an RF planning tool to carry out the RF design is illustrated.

Intended Audience

This detailed technical course is intended for design, engineering, performance optimization and related job functions.

Objectives

After completing this course, the student will be able to:

- Describe how the 5G air interface and the network infrastructure help deliver target 5G services
- Explain beamforming and MIMO concepts and list propagation models suitable for mmWave
- Specify key 5G RF design inputs and calculate the downlink and uplink cell capacity and throughput
- Explain components of a 5G link budget for different services and compare with LTE link budget
- Summarize the planning process for different RF configuration and operational parameters
- Illustrate steps of 5G RF design process, including traffic mapping and propagation modeling
- List the steps for 5G RF design using an RF Planning tool

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: 5G NR Air Interface (Instructor-led)
- Required Equipment: Laptop with RF propagation tool supporting 5G NR

Outline

1. 5G Air Interface Essentials
   1.1 5G Use Cases and Performance Goals
   1.2 5G NR Technology
   1.3 5G NR Numerology
   1.4 DL and UL Channels and Signals
2. MIMO, Beamforming and Propagation Models
   2.1 MIMO and Beamforming in LTE
   2.2 MIMO Techniques in 5G NR
   2.3 Propagation Models
3. 5G Throughput and Capacity
   3.1 DL Throughput and Cell Capacity
   3.2 UL Throughput and Cell Capacity
4. 5G NR Link Budget
   4.1 Principles of Link Budget
   4.2 UL Link Budget for 5G
   4.3 DL Link Budget for 5G
   4.4 Factors Affecting Link Budget
5. 5G RF Parameter Planning
   5.1 PCI Planning
   5.2 Random Access Planning
   5.3 NR Carrier Add/Mod
   5.4 Uplink Power Control
   5.5 TA and RNA Planning
6. 5G RF Design
   6.1 5G RF Design Process
   6.2 5G RF Planning Tool Process
   6.3 5G RF Design – Site Selection
7. RF Planning Tool
   7.1 Key Parameters in RF Planning Tool
   7.2 Project Configuration
   7.3 Site Configuration
   7.4 5G Analysis

View Curriculum
MEC Architecture and Operations Overview

Multi-Access Edge Computing (MEC) pushes cloud computing capabilities closer to the user across multiple access network domains. This course provides an overview of MEC framework, underlying technology and its use cases. The course starts with the definition of MEC, its characteristics, benefits, and business drivers. The MEC architecture defined by ETSI is illustrated. Technology enablers for MEC such as the cloud infrastructure, NFV, SDN, CUPS, Microservices, and 5G core are discussed. MEC location strategies are summarized. The course concludes with a discussion on challenges faced by MEC.

Outline

1. Edge Computing and Enablers
   1.1 Defining MEC
   1.2 Business drivers
   1.3 Key enablers of MEC
   1.4 Cloud infrastructure
   1.5 CUPS Architecture in 4G LTE
   1.6 Virtualizing Core
   1.7 Software-Defined Networking (SDN)

2. Network Architecture for MEC
   2.1 4G EPC and 5G Core Networks
   2.2 Service Based Architecture (SBA) in 5GC
   2.3 Role of NSSF and NEF
   2.4 MEC standardization (e.g., ETSI and 3GPP)
   2.5 ETSI reference architecture
   2.6 Mobile Edge Host (platform, infrastructure, applications)
   2.7 MEC management (host-level, system level)
   2.8 Mobile Edge Services
   2.9 Example MEC APIs

3. MEC Enablers in 5G
   3.1 5G NR features for lower latency
   3.2 5G RAN features for lower latency
   3.3 Virtualizing RAN
   3.4 Selective Routing for MEC
   3.5 MEC in 5G (CAPIF, LADN, PDU Session)
   3.6 Cloud native Microservices
   3.7 Orchestration

4. Deployment and Use Cases
   4.1 MEC server location strategies
   4.2 Authentication and Security
   4.3 Example flow of MEC Operation
   4.4 Sample Use Cases
   4.5 Challenges and key considerations

Key Takeaways
5G Voice Solutions - VoNR and EPS Fallback

This course describes the end-to-end 5G network (5GC, NG-RAN and IMS) and related operations for implementation of Voice over New Radio (VoNR). It provides key features and functionalities for the VoNR service including descriptions of the signaling procedures for IMS registration, Call Setup and release. The course also provides the description and signaling required for EPS fallback to VoLTE and procedures for emergency calling in 5G. The architecture for these services is described together with call flows showing the relationships between network functions in the 5G and 4G RAN and core systems and the IMS and PCC networks. The course will provide hands on exercises for students using log files if available.

Outline

1. Voice services in 5G
   1.1 4G, 5G and IMS network architecture
   1.2 Introduction to EPS Fallback
   1.3 Introduction to VoNR
   Exercise: Voice Services Exercise

2. 5G and IMS Registration
   2.1 Voice with IMS and VoNR
   2.2 IMS Pre-Call Functions
   2.3 IMS Registration
   Exercise: 5G and IMS Registration

3. EPS Fallback
   3.1 EPS and RAT Fallback
   3.2 Call Origination with EPS Fallback
   3.3 Call Termination with EPS Fallback

4. Voice over NR (VoNR)
   4.1 VoNR Call Model
   4.2 Call Setup
   4.3 Resource Establishment
   4.4 Call Termination
   Exercise: VoNR exercise

5. Emergency calls in 5G
   5.1 E-Call in 5G with VoNR
   5.2 Call Setup – Pre-conditions Assumed
   5.3 E-Call Using EPS Fallback
   Exercise: Emergency calls in 5G

Intended Audience

This technical course is intended for planning, design, engineering and operations personnel who need an understanding of VoNR and EPS Fallback in 5G.

Objectives

After completing this course, the student will be able to:

- Sketch the architecture for voice services in 5G
- Describe the VoNR and EPS fallback services
- Illustrate the signaling flow for VoNR calls in 5G
- Describe the codecs used for VoNR
- Sketch the signaling procedures for EPS fallback
- Identify call flows for emergency services in 5G

What You Can Expect

- Expert-Led Live Duration: 16 HOUR
- Prerequisite: 5G Networks and Services
- Prerequisite: Working knowledge of VoLTE, LTE and IMS operations
- Required Equipment: PC with access to Wireshark

View Curriculum
Title: LTE-M and NB-IoT Signaling and Operations

Description:
LTE-M and NB-IoT in the Low Power Wide Area (LPWA) cellular deployment have requirements such as low cost, enhanced coverage, high capacity, and long battery life. This course describes network architecture enhancements in LTE networks for IoT such as NIDD and SCEF. The fundamental operations such as network acquisition, random access, RRC connection setup, data transfer, and mobility are covered. This course requires message traces provided by the customer to step through various scenarios and exercises.

Intended Audience:
Technical personnel working for wireless operators, equipment and device manufacturers, who need a detailed look at LTE-M/eMTC and NB-IoT.

Objectives:
After completing this course, the student will be able to:
- Describe key features of LTE-M and NB-IoT
- Illustrate the network architecture with LPWA enhancements
- Explain how of PSM and eDRX help increase UE battery life
- Describe how EAB and optimized TAU reduce the signaling load
- Summarize key parameters of System Information messages for LTE-M and NB-IoT
- Discuss Attach enhancements for LTE-M and NB-IoT
- Describe key operational configurations of LTE-M and NB-IoT physical channels
- List main KPIs for LTE-M and NB-IoT

What You Can Expect:
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: LTE Overview (self-paced eLearning)
- Prerequisite: Technology Primer: LTE-M & NB-IoT

Outline:
1. Network and Device Architecture
   1.1 MTC, eMTC, NB-IoT, & EC-GSM
   1.2 LTE network enhancements (e.g., NIDD and SCEF)
   1.3 APIs toward customer AS: OMA, OneM2M, and RESTful APIs
   1.4 External device identifiers
   1.5 UE module industry overview
   1.6 UE architecture
2. LPWA IoT-centric Features
   2.1 Wireless optimizations for IoT
   2.2 Power Save Mode (PSM)
   2.3 eDRX in Connected and Idle modes
   2.4 High latency communication
   2.5 Extended Access Barring (EAB)
   2.6 Optimized TAU signaling
   2.7 Half Duplex (HD) FDD
   2.8 eMBMS for IoT
3. LTE-M: A Closer Look
   3.1 Characteristics of UE category M1
   3.2 CE Mode A and CE Mode B
   3.3 MIB, SIB1-BR, and SIB2
   3.4 LTE-M Random Access
   3.5 RRC Connection Setup for LTE-M
4. NB-IoT: A Closer Look
   4.1 Overview of UE category NB1
   4.2 Deployment scenarios (in-band, guard band, and standalone)
   4.3 Category NB1 multicarrier support
   4.4 Network acquisition in NB-IoT
   4.5 MIB-NB and System Information
   4.6 Random Access in NB-IoT
   4.7 NB-IoT RRC Connection Setup
   4.8 NB-IoT Attach enhancements
   4.9 NPDCCH configuration
   4.10 NPDSCH, NPUCC & NPUSCH for NB-IoT data transfer
   4.11 NB-IoT KPIs
5. Additional Material
   5.1 APIs (OMA, OneM2M, & RESTful) and IoT Protocols (MQTT-SN, CoAP, & Non-IP)
   5.2 UE location determination methods
   5.3 IoT enhancements in EC-GSM

View Curriculum
5G (SA) RAN Signaling and Operations

This course takes an in-depth look at the life of a 5G device in the context of Standalone (SA) option 2 deployment. It describes successful scenarios through signaling call flows. It steps through key operations such as power up and system acquisition, RRC connection setup, bearer setup with 5G NR, and DL and UL operations on 5G NR. This course covers key operations through call flows with details of major messages and their key parameters. The course helps students with an in-depth understanding of successful call flows for Option 2 based signaling and bearer paths.

Intended Audience

This detailed technical course is intended for engineering, systems performance, and operations related job functions who need to get an in-depth understanding of signaling procedures of SA NR with the 5GC deployment.

Objectives

After completing this course, the student will be able to:
- Step through the life of a 5G UE in SA (Option 2) deployment
- Identify steps of preparing to monitor 5G cell and 5G network acquisition
- Identify steps of RRC connection setup with the gNB
- Identify key steps of registering and setting up PDU session in SA
- Explore the role of beamforming in DL and UL traffic operations
- Step through the handover and mobility operations

What You Can Expect

- Self-Paced Duration: 9 HOUR
- Expert-Led Live Duration: 15 HOUR
- Total Program Duration: 4 WEEK
- Prerequisite: 5G NR Air Interface (Instructor-led)

Outline

1. 5G SA (Option 2) Network
   1.1 End-to-end SA Architecture
   1.2 Use of Interfaces: NR, N1, N2, N3, Xn
   1.3 Role of protocols like PHY, MAC, RRC, PDCP, etc.
   1.4 NR Numerology and Frame structure
   1.5 Use of DL and UL Physical signals and Channels
   1.6 Role of Beamforming and MIMO

2. 5G Cell Acquisition and RACH Procedure
   2.1 Synch Raster and Synchronization
   2.2 Cell ID and Beam ID Detection
   2.3 MIB and System Information Blocks(SIBs)
   2.4 Random Access Operation
   2.5 UE and gNB Timing Alignment
   2.6 RRC Setup and Indication for Network Slice

3. SME Led Session [Live Web-based]
   Exercise: 5G SA Operations and 5G Cell Acquisition

4. Registration and PDU Session Setup
   4.1 Registration and Authentication
   4.2 AMF, SMF and UPF Selection
   4.3 As and NAS Security
   4.4 QoS Parameters in 5G
   4.5 PDU Session Setup

5. SME Led Session [Live Web-based]
   Exercise: Registration and PDU Session Setup

6. Traffic Operations in DL
   6.1 CSI-RS Measurement Configuration
   6.2 Feedback - CQI,PMI,RI,CR,Li
   6.3 Resource Allocation for DL
   6.4 CSI-RS reports for Beam Selection and for MCS
   6.5 Carrier Aggregation and Band combinations

7. SME Led Session [Live Web-based]
   Exercise: Traffic Operations in DL

8. Traffic Operations in UL
   8.1 Scheduling Request (SR) & BSR
   8.2 Resource Allocation for UL
   8.3 UL Power Control
   8.4 DCIs for UL operation

9. SME Led Session [Live Web-based]
   Exercise: Traffic Operations in UL

10. Handover and Idle Mode Operations
    10.1 Beam Management - Switching, monitoring
    10.2 MAC CE changes of TCI state
    10.3 Xn and N2 based Handover
    10.4 Idle Mode Mobility

11. SME Led Session [Live Web-based]
    Exercise: Handover and Idle Mode Operations

Final Assessment
Introduction to 5G

5G promises to enable a wide variety of new wireless communications services and capabilities, ranging from high-speed high-capacity broadband access to extremely reliable low-latency communications to machine-type communications on a massive scale. In order to deliver on these promises, everything about the wireless network must change, including the devices, the radio interface, the radio access network (RAN), and the core network. This course provides an overview of the usage scenarios envisioned by the wireless industry and highlights the changes and enhancements being defined in the 3GPP standards. This course is delivered in a blended format, including two live web sessions along with self-paced multimedia content, allowing students to learn in bite-sized chunks over a three-week interval.

Intended Audience
This blended (self-paced and instructor-led) course is intended for a technical audience looking for an overview of the drivers for 5G and a basic understanding of the underlying technologies being considered.

Objectives
After completing this course, the student will be able to:
- Describe the 5G usage scenarios defined by the ITU and 3GPP
- Identify the technology building blocks needed for 5G
- Explain the key enhancements to the 5G RAN and core network architectures
- Discuss benefits of enhanced network capabilities, such as MEC, network slicing, and C-RAN
- Identify the new spectrum bands being considered for 5G
- Discuss radio interface enhancements
- Illustrate the key 5G deployment scenarios

What You Can Expect
- Self-Paced Duration: 6 HOUR
- Expert-Led Live Duration: 2 HOUR
- Total Program Duration: 4 WEEK
- Prerequisite: Welcome to 5G (eLearning)

Outline

1. Kickoff Session [Live: Web-based]
   1.1 Getting the most out of the course
   1.2 5G overview

2. Introduction to 5G Services
   2.1 ITU/3GPP usage scenarios
   2.2 5G performance targets
   2.3 5G technology building blocks

3. Introduction to 5G Networks
   3.1 5G RAN and core network architectures
   3.2 Mobile Edge Computing (MEC)
   3.3 Network slicing
   3.4 Cloud RAN (C-RAN)
   3.5 5G deployment options

4. Introduction to 5G New Radio
   4.1 5G spectrum
   4.2 Massive MIMO
   4.3 5G radio enhancements
   4.4 5G channel coding
   4.5 5G transport

5. Checkpoint Session [Live: Web-based]
   5.1 Q&A
   5.2 5G industry update
5G (NSA) RAN Signaling and Operations

This course takes an in-depth look at the life of a 5G device in the context of Non-Standalone (NSA) Option 3x deployment. It describes successful scenarios through signaling call flows. It steps through key operations such as power up and system acquisition, RRC connection setup, bearer setup with 4G LTE and 5G NR, and DL and UL operations on 5G NR. This course covers key operations through call flows with details of major messages and their key parameters. The course will help students with an in-depth understanding of successful call flows for Option 3x-based signaling and bearer paths.

Objectives

After completing this course, the student will be able to:
- Illustrate the architecture of Option 3x-based NSA deployment
- Sketch and describe the frame structure with numerology of the 5G NR air interface
- Identify key steps of preparing to monitor 5G cell and 5G network acquisition
- Identify key steps of random access and RRC connection setup
- Step through the data transfer operations in DL using different bearers (e.g., a split bearer)
- Step through the data transfer operations in UL using different bearers (e.g., a split bearer)
- Step through the handover and mobility operations for adding, modifying, and removing SgNB

What You Can Expect

- Self-Paced Duration: 10 HOUR
- Expert-Led Live Duration: 14 HOUR
- Total Program Duration: 5 WEEK
- Prerequisite: 5G NR Air Interface (Instructor-led)

Outline

1. SME Led Session [Live Web-based]
   1.1 Kickoff: 5G (NSA) Option 3x Network Operations

2. 5G NSA Network Architecture
   2.1 NSA Option 3x network architecture
   2.2 Signaling and data radio bearers in Option 3x
   2.3 Overview of EN-DC operations
   2.4 5G UE capability transfer

3. 5G Cell Acquisition
   3.1 Configuration for NR cell measurements
   3.2 SS/PBCH block
   3.3 NR cell measurements
   3.4 Measurement Report by 5G UE
   3.5 eNB-gNB X2 setup
   3.6 Overview of SgNB addition
   3.7 RRC Connection Reconfiguration for SgNB addition

4. SME Led Session [Live Web-based]
   Exercise: 5G NSA Operations and 5G Cell Acquisition

5. Connecting to 5G gNB: Random Access
   5.1 Overview of random access
   5.2 PRACH configurations and radio resources
   5.3 Uplink synchronization in an NR cell

6. DL Data transfer in 5G
   6.1 DL signals and UE measurements
   6.2 5G measurements by UE

7. SME Led Session [Live Web-based]
   Exercise: Random Access and DL Data Transfer

8. UL Data Transfer in 5G
   8.1 Overview of UL traffic processing
   8.2 Scheduling requests
   8.3 Buffer status reports
   8.4 Resource allocation for UL
   8.5 UL data transmission
   8.6 Uplink power control

9. Mobility and Idle Mode Operations
   9.1 Mobility and RRC states
   9.2 Mobility scenarios
   9.3 Measurements and handover signaling
   9.4 5G connection release
   9.5 Idle mode mobility

10. SME Led Session [Live Web-based]
    Exercise: UL Data Transfer, Mobility Operations

Final Assessment

Intended Audience

This detailed technical course is intended for engineering, systems performance, and operations related job functions who need to get an in-depth understanding of signaling procedures of NSA NR with the EPC deployment.

What You Can Expect

- Self-Paced Duration: 10 HOUR
- Expert-Led Live Duration: 14 HOUR
- Total Program Duration: 5 WEEK
- Prerequisite: 5G NR Air Interface (Instructor-led)
5G (NSA) RAN Performance Workshop: Part 1

This workshop helps RAN engineers troubleshoot and optimize 5G NSA based RAN using market KPIs, vendor counters and parameter settings. Students use their tools for analyzing network performance. In addition, this workshop also introduces new features being deployed so students become familiar with the enhancements to their network. Instructor-led exercise sessions use signaling messages captured from live case studies (where available) to ensure the key learnings of the course material are reinforced.

Intended Audience
This performance troubleshooting workshop is intended for Systems and RAN Performance engineers.

Objectives
After completing this course, the student will be able to:
- List the 5G NSA RAN KPIs that impacts network performance
- Identify the factors and events that impact 5G NSA RAN KPIs
- Analyze KPIs related to Accessibility, Retainability, Throughput, Handover
- Understand the signatures that result into poor performance
- Step through key operations of new features like DSS, PDCP Aggregation, etc.
- Analyze various scenarios of poor performance and present the findings

What You Can Expect
- Self-Paced Duration: 17 HOUR
- Expert-Led Live Duration: 15 HOUR
- Total Program Duration: 6 WEEK
- Prerequisite: 5G NR Air Interface
- Prerequisite: 5G (NSA) RAN Signaling and Operations
- Required Equipment: Access to the KPI dashboards and network monitoring tools

Outline
1. Workshop Pre-Learning
   1.1 5G (NSA) RAN KPIs
   1.2 Accessibility, Retainability, Integrity, Handovers

2. SME Led Session [Live Web-based]
   2.1 5G (NSA) RAN KPIs definitions
   2.2 Tools and KPI dashboards
   2.3 New features - DSS, PDCP Aggregation, etc.

3. Accessibility Analysis
   3.1 SgNB Cell add success
   3.2 RACH success
   3.3 Call flow, Counter triggers, and KPIs
   *Exercise: Accessibility problem analysis
   3.4 Impact of coverage of low, mid, high band for 5G

4. SME Led Session [Live Web-based]
   4.1 Accessibility analysis walk-through
   *Exercise: Case Studies: SgNB Addition and RACH failure
   *Exercise: Student Exercises

5. Retainability Analysis
   5.1 UE detected radio link failures
   5.2 eNB and gNB detected radio link failures
   5.3 Call flow, Counter triggers, and KPIs
   *Exercise: Retainability problem analysis
   5.4 Beam management enhancements

6. SME Led Session [Live Web-based]
   6.1 Retainability analysis walk-through
   *Exercise: Student Exercises

7. Throughput and Latency Analysis
   7.1 UE and cell throughput and latency analysis
   7.2 Role of Dynamic Spectrum Sharing (DSS)
   7.3 Split bearer and PDCP Aggregation
   7.4 UL on 5G NR
   7.5 Call flow, Counter triggers, and KPIs
   *Exercise: Throughput problem analysis

8. SME Led Session [Live Web-based]
   8.1 Throughput and Latency analysis walk-through
   *Exercise: Case Studies: Low Throughput
   *Exercise: Student Exercises

9. Mobility and Handover Analysis
   9.1 Intra-CU and Inter-CU Handovers
   9.2 Stages of Handover
   *Exercise: Handover problem analysis

10. SME Led Session [Live Web-based]
    10.1 Handover analysis walk-through
    *Exercise: Case Studies: Anchor and SgNB HO failures
    *Exercise: Student Exercises

Student Presentations
Final Assessment
5G Core Network Signaling and Operations

The 5G Core (5GC) network architecture is a significant evolution from the 4G LTE EPC. Network functions have been de-composed and re-architected to enable more flexible usage of network resources. Multi-Access Edge Computing (MEC) and Network Slicing are new capabilities that permit the operator to hone the network to meet specific applications' requirements, for example very low latency. The 5GC architecture enables implementation in virtualized networks. Students will step through various network operations and related call flows using actual logs where applicable and will be able to highlight key differences of 5G operations from LTE operations.

Intended Audience
This technical course is intended for planning, design, engineering and operations related job functions who require a detailed understanding of the 5G core network architecture and operations.

Objectives
After completing this course, the student will be able to:
- Identify the Network Functions (NF) of the 5G core network and their roles in the 5GC
- Sketch the connectivity for the 5G network functions
- Describe the 5G UE registration procedure
- Describe PDU session setup procedures and the relationship to QoS in 5G
- Identify the 5G core components for user traffic routing
- Step through the procedures for Idle mode and connected mode mobility
- Describe the procedures for network slice assignment and selection for a 5G UE
- Illustrate the architecture for MEC and describe traffic flow for MEC applications

What You Can Expect
- Self-Paced Duration: 10 HOUR
- Expert-Led Live Duration: 14 HOUR
- Total Program Duration: 5 WEEK
- Prerequisite: 5G Core Network Overview (self-paced eLearning)
- Prerequisite: 5G Networks and Services (Instructor-led)

Outline

1. SME Led Session [Live Web-based]
   1.1 Kickoff

2. 5G Network Architecture
   2.1 End-to-end 5G NG-RAN to 5GC architecture
   2.2 5GC Network Functions - AMF, SMF, etc.
   2.3 SBA, APIs and NRF
   2.4 5G and virtualization technologies
   Exercise: 5GC Network Functions

3. Network Slicing and MEC
   3.1 3GPP defined use cases
   3.2 UE slice assignment and requests
   3.3 SMF and UPF assignment for slices
   3.4 MEC deployment options and traffic flow
   3.5 MEC and NEF
   Exercise: Network Slicing and MEC

4. SME Led Session/Exercises [Live Web-based]

5. 5G UE Registration Procedure
   5.1 5G Identifiers and UE States
   5.2 Initial Registration
   5.3 Network slicing and AMF selection
   5.4 Authentication using AUSF and UDM
   5.5 A5 and NAS Security
   Exercise: Registration call flow

6. PDU Session Establishment
   6.1 User Plane Traffic Path
   6.2 UE signaling for PDU Session Establishment
   6.3 SMF and UPF selection
   6.4 UE signaling for PDU Session Modification
   6.5 UE signaling for PDU Session Release
   6.6 UE signaling for UP deactivation/re-activation
   6.7 UE signaling for UP
   Exercise: PDU Session Management call flows

7. SME Led Session/Exercises [Live Web-based]

8. QoS in 5G
   8.1 5G Quality of Service (QoS)
   8.2 PCF and QoS enforcement
   8.3 Use of multiple UPFs
   8.4 IMS Services in 5G and GBR flow establishment
   8.5 External application access and NEF
   Exercise: QoS Management

9. Mobility and Interworking with LTE
   9.1 Idle Mode Mobility
   9.2 Connected Mode Mobility - Xn HO
   9.3 Connected Mode Mobility - N2 HO
   9.4 Session continuity
   9.5 Interworking with 4G LTE
   Exercise: Mobility Management

10. SME Led Session/Exercises [Live Web-based]
Automation and Insights
Automation and Insights

2020 Course Roadmap

SELF-PACED
Welcome to AI

TECH PRIMER
Automation
Artificial Intelligence (AI)
Analytics
Machine Learning

Data Automation Workshop using Python
Data Automation Mentoring Program

Ansible Workshop

Data Visualization Workshop using PowerBI

Analytics Workshop

Machine Learning Workshop

Deep Learning Concepts Workshop
Automation and Insights

We help our customers tackle technology, faster.

Curriculums include:

- SELF-PACED
  - Welcome to AI

- BLENDDED
  - Data Automation Mentoring Program

- EXPERT-LED LIVE
  - Automation
  - Artificial Intelligence (AI)
  - Analytics
  - Machine Learning
  - Data Automation Workshop using Python
  - Ansible Workshop
  - Data Visualization Workshop
  - Data Visualization Workshop using PowerBI
  - Data Visualization Workshop for Leaders
  - Analytics Workshop
  - Machine Learning Workshop
  - Deep Learning Concepts Workshop
Welcome to AI

Artificial Intelligence (AI) technologies are reshaping how telecom service providers’ networks operate resulting in more efficient operation that reduces costs and increases savings. Together, these solutions allow networks to operate at web-scale and provide customers with unprecedented levels of agility and flexibility. This course gives an overview of AI, describes the AI and automation lifecycle, and details AI’s impact on the telecom industry. In addition, several AI use cases are explored.

Intended Audience

The course is intended for all audiences that are interested in understanding how Automation and AI are changing the telecommunications industry.

Objectives

After completing this course, the student will be able to:

- Give examples of AI in action
- Sketch the AI and Automation Lifecycle
- Articulate how AI changes the telecommunications industry
- List some of the AI Use Cases

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. What is AI?
   1.1 Types of AI
   1.2 Define in nine

2. AI concepts
   2.1 AI terms and concepts

3. Neural Networks
   3.1 What is Neural Networks?
   3.2 Neural Networks in action

4. AI and Automation lifecycle
   4.1 Lifecycle overview
   4.2 Model creation
   4.3 Model Deployment
   4.4 Automation and Human Intervention
   4.5 AI and Automation Lifecycle in the Telecom Industry

5. Impact of AI on Telecom
   5.1 AI, Analytics and Automation
   5.2 Strategic goals
   5.3 Priority areas for CSP AI, ML activities

6. AI focus areas
   6.1 Interaction focus, Complex communication
   6.2 Pattern detection, Process automation, Decisioning

7. AI Use Cases in Telecom
   8.1 Streaming Service, IoT
   8.2 VR/AR
   8.3 Autonomous cars

8. AI Use Cases that impact a Telecom Network
   8.1 Streaming Service, IoT
   8.2 VR/AR
   8.3 Autonomous cars

9. Course Summary

Welcome to AI

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9. Course Summary
Technology Primer: Automation

5G and virtualized/containerized networks bring a new level of complexity and data. In this new world, the ability to automate tasks has become more critical to maintain and optimize networks. This course provides an overview of automation and how it can be used within the telecom industry. Automation is explored from a definition, functional and specific uses perspective. It starts with an introduction to automation. The course then moves to use cases and an exploration of two key tools that are used today for automation, Python and Ansible. The course concludes with a discussion on data visualization, which can be used in conjunction with automation tools to help analyze data.

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks

Objectives
After completing this course, the student will be able to:
- Describe Automation
- Compare key automation use cases
- Describe Python functions and use cases
- Describe Ansible functions and use cases
- Explore data visualization

What You Can Expect
- Expert-Led Live Duration: 4 HOUR

Outline

1. Automation Overview
   1.1 Goals of Automation
   1.2 Process of Automation

2. Automation Use Cases
   2.1 Automation Use Case Criteria
   2.2 Automation Needs

3. Automation and Python
   3.1 What is Python?
   3.2 Python, Libraries and Automation

4. Automation and Ansible
   4.1 What is Ansible?
   4.2 Ansible and DevOps

5. Data Visualization
   5.1 Why Visualize Data?
   5.2 Data Visualization Big Picture
Technology Primer: Artificial Intelligence (AI)

Artificial Intelligence (AI) is revolutionizing all aspects of the computer industry. The impacts of AI have been seen on a number of areas such as speech and image recognition. The telecom industry is different. This course provides an overview of AI from a telecom perspective. AI is explored from a definition, underlying technology and use-cases perspective. It starts with an introduction to AI. The course then moves to key AI use cases and the AI technologies of Machine Learning and Deep Learning. The course concludes with a discussion on how to build an AI model, some of the common tools, and the key challenges.

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks

Objectives
After completing this course, the student will be able to:
- Define Artificial Intelligence (AI)
- List the key use cases within telecommunications for AI
- Compare and contrast deep learning and machine learning
- List different AI design models

What You Can Expect
- Expert-Led Live Duration: 4 HOUR

Outline

1. Introduction to AI
   - 1.1 AI defined
   - 1.2 Types of AI
   - 1.3 Common non-telecom AI use cases

2. Service Provider AI Use Cases
   - 2.1 How is telecom different?
   - 2.2 Telecom use cases
   - 2.3 Customer support
   - 2.4 Engineering and planning
   - 2.5 Retail and supply chain
   - 2.6 Workforce management
   - 2.7 Telecom impacting use cases
   - 2.8 Autonomous driving
   - 2.9 IoT

3. AI, Machine Learning, and Deep Learning
   - 3.1 Machine Learning and Deep Learning defined
   - 3.2 How to train an AI model
   - 3.3 Types of Machine Learning
   - 3.4 Impacts of data on Machine Learning model

4. Basics of Building an AI Model
   - 4.1 Common AI tools
   - 4.2 Key AI model structure
   - 4.3 Types of neurons
   - 4.4 Challenges and key considerations

View Curriculum
In the age of Automation and AI, statistics are critical in developing automation capabilities or just understanding how AI works. This course provides an overview of statistics and analytics that are used within the telecom industry. Statistics principles are explored from a definition, functional and specific uses perspective. It starts with an introduction to Data Science Fundamentals. The course then moves to key Statistical Analysis and Inference techniques. The course concludes with a discussion on Time Series and the uses within the telecom industry.

## Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks.

## Objectives
After completing this course, the student will be able to:
- Describe Statistical Analysis
- Describe Inference
- Describe Linear Regression
- Describe Logistic Regression
- Analyze Time Series

## What You Can Expect
- Expert-Led Live Duration: 4 HOUR

### Outline

1. **Data Science Fundamentals**
   - 1.1 Measures of central tendency
   - 1.2 Measures of Dispersion
   - **Exercise:** Use Case Example

2. **Statistical Analysis**
   - 2.1 Hypothesis testing
   - 2.2 Type I and Type II Error
   - 2.3 Correlation Analysis
   - **Exercise:** Hypothesis Testing Examples

3. **Inference**
   - 3.1 Linear Regression interpretation
   - 3.2 Logistic Regression interpretation
   - **Exercise:** Linear vs. Logistic Regression Examples

4. **Time Series**
   - 4.1 Introduction to Time Series
   - **Exercise:** Time Series Example

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**Technology Primer: Analytics**

**View Curriculum**
Technology Primer: Machine Learning

In the age of Automation and Artificial Intelligence, Machine Learning, or ML, has become the dominant AI approach. This course provides an overview of what ML and Deep Learning are and how they are used within the telecom industry. A high-level description of the main types of models used in ML (i.e., Feed Forward, Convolutional Neural Network, Long Short Term Memory, etc.) and the use cases where they are proven valuable is discussed. Overview of the training process is also explored. The course concludes with practical examples demonstrated to see ML in action.

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks

Objectives
After completing this course, the student will be able to:
- Describe Machine Learning and Deep Learning
- Describe Model Building
- Explain how a model learns
- Compare various Machine Learning Models

What You Can Expect
- Expert-Led Live Duration: 4 HOUR

Outline
1. Machine Learning and Deep Learning
   1.1 Machine Learning Defined
   1.2 Types of Learning
   1.3 ML Lifecycle
2. ML Model Building
   2.1 Types of Models
   2.2 Key Parameters in Building
   2.3 Models and Data
   2.4 ML and Hardware
3. ML Model Training
   3.1 What are we training?
   3.2 Success Criteria
   3.3 Training Parameters and Time
4. ML Models Compared
   4.1 Key Types of ML models
   4.2 ML Model Use Cases

View Curriculum
Data Automation Workshop using Python

The Data Automation Workshop using Python is designed for non-programmers who want to create programs in Python to help them automate some of their mundane daily tasks related to gathering and analyzing data. By using hands-on, lab-based programming exercises, it takes the student on a practical guided tour of Python’s capabilities and throughout the session create several practical and useful Python programs. The workshop provides an opportunity to define and develop a Python program based on a practical and relevant use case.

Intended Audience
This workshop is intended for anyone (non-programmers) who wants to build knowledge and skills related to leveraging data tools to be more productive.

Objectives
After completing this course, the student will be able to:
- Analyze a problem and design step-by-step ways to automate the task at hand
- Learn how to manage data in different forms of data structures to load and manipulate data
- How to use key control structures to manage the process flow
- Implement solutions based on string manipulation, regular expression processing and loops
- Implement a data processing exercise using control and data structures including file operations
- Implement text file and Excel file handling for Input/Output processing
- Learn how to automate data collection through APIs
- Python is used as the programming language for all exercises and lab-work

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Basic knowledge of Excel
- Required Equipment: Students will need a laptop with MS-Excel and Python

Outline
1. Get started with Python
   1.1 Create a Python program
   1.2 Run a Python program
   1.3 Import and Modules/Packages
   1.4 Conditional statements
   1.5 For and while loops
   1.6 Functions
   1.7 Lists
   1.8 Dictionary
   1.9 String Operations
   Exercise: Create and Run a Program
2. Processing Data from Text Files
   2.1 Text File Processing basics
   2.2 Command line arguments in Python
   2.3 Python File Operations
   2.4 File reading and writing
   2.5 Python to walk a directory
   2.6 Counting lines, words
   Exercise: Read a file, count lines, words and develop word length vs. frequency data
   Exercise: Define a class-specific use case
   Exercise: Develop a Python program to implement the use case
3. Processing Data from Excel Workbooks
   3.1 What is Openpyxl?
   3.2 Installing Openpyxl module
   3.3 Creating a Workbook
   3.4 Reading data from a Workbook
   3.5 Creating and naming Worksheets
   3.6 Deleting a Worksheet
   3.7 Excel Object Structure
   3.8 Reading and writing to/from a cell
   3.9 Inserting Formulas into Excel Sheets from Python Programs
   3.10 Formatting rows and columns
   3.11 Inserting Excel Charts in Python
   3.12 Saving an Excel Workbook
   Exercise: Create an Excel file, insert data from text file processing and plot a chart
4. Data gathering from Websites and Applications
   4.1 Concept of APIs
   4.2 Using APIs in Python
   4.3 Invoke API on a Web Server
   4.4 Capture the response
   4.5 Save the response to a file
   4.6 Invoke API on an App Server
   4.7 Capture the response
   4.8 Save the response to a file
   Exercise: Invoke APIs from Python

View Curriculum
Ansible Workshop

Automation and orchestration are becoming key factors in successful network deployment and operations. Ansible is an important tool that uses a declarative mechanism and often is used as part of DevOps. In this workshop, you will learn the Ansible components and use Ansible to automate the deployment, configuration and updates of Ansible targets such as virtual machines. The workshop provides a hands-on opportunity to build playbooks and their dependencies. In addition, the workshop enables the use of several Ansible features including the use of Ansible vault, rolling updates, variables, redirection, custom modules, and plugins.

Outline

1. Ansible Overview
   1.1 Introduction to Ansible
   1.2 Ansible applications in NFV clouds
   1.3 Ansible and other DevOps tools
   Exercise: Lab setup

2. Ansible Environment
   2.1 Introduction to YAML templates
   2.2 Ansible environment
   2.3 Ansible CLI
   Exercise: Using Ansible CLI

3. Ansible Playbook
   3.1 Playbook structure
   3.2 Ansible modules
   3.3 Inventories, roles, handlers, etc.
   Exercise: Building a playbook

4. Ansible Playbook Extensions
   4.1 Variables, variable arrays, and lookup
   4.2 Facts and custom facts
   4.3 Variable substitutions

5. Ansible Interactions
   5.1 Applying scopes and precedence
   5.2 Various Ansible modules
   Exercise: Extend the playbook to use different modules

6. Further Ansible Automation
   6.1 Assertions
   6.2 Redirection
   6.3 Output formatting for readability
   Exercise: Extend playbook with further automation

7. Additional Ansible Features
   7.1 Ansible vault
   7.2 Rolling updates
   7.3 Failure percentage
   7.4 Ansible Galaxy
   Exercise: Update playbook to use features of interest

Objectives

After completing this course, the student will be able to:
- List ansible features
- Explain the benefits of the main Ansible component
- Demonstrate building and enhancing playbooks
- Construct Ansible playbooks using various modules
- Perform various Ansible CLI commands
- Apply different features such as vault, plugins, etc.
- Summarize the value of Ansible in DevOps
- Demonstrate playbook re-usability

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Basic Linux operating system skills are recommended
- Required Equipment: Laptop/desktop with Internet connectivity

Intended Audience

A hands-on in-depth technical training to personnel involved in design, engineering, operations and monitoring of networks.
Data Visualization Workshop

Telecom networks are continuing to transform in fundamental ways - cloud platforms are enabling networks to be run as software-based functions. This enables the management of these networks to become software centric and thus require the use of scripting and software-oriented approaches to automate tasks performed on these networks. Industries are starting to leverage feature-rich tools that analyze massive, varied data sets to complete tasks more productively and effectively. This course teaches techniques by taking large datasets of network performance data and creating close to 50 visualizations. This includes visualizations like Line Charts, Scatter Maps, Tree Maps, Heat Maps, Box-Whisker Maps, Histograms and covers the use of Joins, Blends, Calculated Fields, Table Calculations, Parameters and Dashboards to create powerful visualizations.

Intended Audience
This workshop is intended for anyone who wants to build knowledge and skills related to leveraging data tools to be more productive.

Objectives
After completing this course, the student will be able to:
■   Connect to a data source
■   Visualize KPIs that change over time
■   Visualize large data sets by leveraging power of Filters
■   Visualize KPIs using Bar Charts, Scatter Maps and Pie Charts
■   Visualize KPIs using Tree Maps, Heat Maps, Box-Whisker Maps
■   Correlate/Compare data with Dual Axis and Histograms
■   Use Joins and Blends to visualize data from multiple sources
■   Visualize geographical data with Filled Maps

What You Can Expect
■   Expert-Led Live Duration: 24 HOUR
■   Prerequisite: Basic knowledge of Excel
■   Required Equipment: Students will need a laptop with access to Tableau Desktop

Outline

1. Tableau Prep for ETL
   1.1 Introduction to the ETL concepts and process
   1.2 Navigation in Prep
   1.3 Understanding the various panes and their functions
   1.4 Extracting data from various sources: Excel, Text/CSV, JSON, Web, Database
   1.5 3 Types of Transformation: Content, Shape, Combine datasets
   1.6 Tall vs Wide Data Sets
   Exercise: Preview Data in Desktop
   Exercise: Load Data Output files
   Exercise: Data Sampling Options in Prep

2. Data Visualization and Tableau
   2.1 Getting started with Tableau
   2.2 Navigation of Tableau
   2.3 Dimensions and Measures
   2.4 Visualizing Time Series
   2.5 Use of Line Charts
   2.6 Filtering Large Data Sets
   2.7 Filtering Techniques
   2.8 Comparing Categorical Data
   2.9 Use of Bar Charts
   Exercise: Connect to data source
   Exercise: Create Tableau Visualizations

3. Data Visualizations
   3.1 Correlating KPIs using Scatter Maps
   3.2 Using granularity for Visualizations
   3.3 Pie Charts
   3.4 Hierarchical data and Tree Maps
   3.5 Visuals with color and Heat Maps
   3.6 Data distribution and Box-Whisker Maps
   3.7 Correlating two KPIs with Dual Axis
   3.8 Using bins and Histograms for comparison
   3.9 Correlating multiple KPIs with Multi-Measure Comparisons
   Exercise: Create Tableau Visualizations

4. Advanced Data Visualizations
   4.1 Joins to visualize two data sources
   4.2 Geographical data and Filled Maps
   4.3 Blends to visualize two data sources
   4.4 Modifying data with calculated fields
   4.5 Table Calculations and aggregated data
   4.6 Parameters for interactive visualizations
   4.7 Using Highlights to draw attention
   4.8 Merging data with Groups
   4.9 Sets
   4.10 Creating a visual narrative with Dashboard and Story
   Exercise: Create Visualizations with Joins and Blends
   Exercise: Create a Dashboard

View Curriculum
Data Visualization Workshop using Power BI

Telecom networks are continuing to transform in fundamental ways - cloud platforms are enabling networks to be run as software-based functions. This enables the management of these networks to become software centric and thus require the use of scripting and software-oriented approaches to automate and manage tasks performed on these networks. Industries are starting to leverage feature-rich tools that analyze massive, varied data sets to complete tasks more productively and effectively. This course teaches data visualization techniques by taking large datasets of network performance data and creating close to 50 visualizations. This includes visualizations like Line Charts, Scatter Maps, Tree Maps, Heat Maps, Box-Whisker Maps, Histograms and covers the use of Joins, Blends, Calculated Columns, Reports and Dashboards to create powerful visualizations.

Outline

1. Getting Started with Power BI
   - Exercise: Connect to a Data Source
   - Exercise: Navigate Power BI Desktop

2. Data Query in Power BI
   2.1 Introduction to ETL
   2.2 Navigate the Query Editor
   2.3 Import Data vs Direct Query
   2.4 3 Types of Transformation: Content, Shape, Combine datasets
   2.5 Tall vs Wide Data Sets
   2.6 Managing the Query List, Applied Steps
   2.7 Load vs Edit
   2.8 Extract from data sources: Excel, CSV, JSON, Web, API, Database
   - Exercise: Extract, Transform, Load

3. Visualizations I
   3.1 Visualization Concepts and Process
   3.2 Dimensions, Measures
   3.3 Relationship View, Data View, Report View
   3.4 Filtering Techniques: Filters, Slicers
   3.5 Tables and Matrices
   3.6 Bar Charts: Simple, Clustered, Stacked
   3.7 Time Series: Discrete vs Continuous
   - Exercise: Create Visualizations in Report View

4. Visualizations II
   4.1 Key features and differences of Pie Charts and Donut Charts
   4.2 Reinforcing data points using Cards and Multirow Cards
   4.3 Play Axis animation in Scatter Charts
   4.4 Troubleshooting using Tree Maps
   4.5 Visuals with colors and Heat Maps
   4.6 Using Histograms for data distribution
   4.7 Grouping and Binning data
   4.8 Geographical data and Filled Maps
   4.9 Understanding the interaction between Visuals to create a Dashboard
   4.10 Report Drill Through
   4.11 Custom KPI in Data View - New Column vs New Measure
   - Exercise: Create a Dashboard

5. Data Modeling for Power BI
   5.1 Introduction to the Data Modeling Concept
   5.2 Dim Tables and Fact Tables
   5.3 Star and Snowflake schema
   5.4 Single vs Bidirectional Relations
   5.5 Creating Date/Time Dimension Tables
   5.6 Leveraging the Time Intelligence Functions of Power BI
   - Exercise: Creating relationships between Dim Tables and Fact Tables

View Curriculum
Data Visualization Workshop for Leaders

Industries are starting to leverage feature-rich tools that analyze massive, varied data sets to complete tasks more productively and effectively. Leaders spend a large amount of time interacting with data and studying the dashboards and visualizations created by their teams. Hence, their perspective of using a Visualization tool is quite different from their teams who need to create the visualizations. This course is focused on Leaders and teaches them techniques to interact with data for What If analysis to help with decision making.

Intended Audience
This workshop is intended for Leaders who want to build skills related to visualizations and interacting with data using Tableau Reader.

Objectives
After completing this course, the student will be able to:
- Connect to a data source
- Visualize KPIs that change over time
- Use Visualizations for What If analysis
- Visualize large data sets by leveraging power of Filters
- Use Dashboards for Visualizations

What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: Basic knowledge of Excel
- Required Equipment: Students will need a laptop with access to Tableau Reader

Outline

1. Introduction to Visualization and Tableau Reader
   1.1 Why use Visualizations?
   1.2 Why use Visualization Tools?
   1.3 The Process for Visualization Design
   1.4 Tableau - Suite of Products
   1.5 Getting started with Tableau Reader
   **Exercise:** Navigation of Tableau Reader

2. Visualization Concepts
   2.1 Dimensions and Measures
   2.2 Continuous and Discrete
   2.3 Time Series - Continuous and Discrete
   2.4 Visualizing Time Series

3. What If Analysis using Tableau Reader
   **Exercise:** Highlighting Data of Interest
   **Exercise:** Filtering Data
   **Exercise:** Using Parameters
   **Exercise:** Using Dashboard Actions
   **Exercise:** Using Playback/Animation
   **Exercise:** Editing Colors
   **Exercise:** Sorting Options
   **Exercise:** Exporting Data

4. Industry Applications for Visualization
   **Exercise:** Putting it All Together
Analytics Workshop

The Analytics Workshop is designed for individuals who are familiar with Python and want to start their journey into the world of Data Analytics. By using hands-on, lab-based programming exercises (using Python, Pandas, Jupyter Notebooks and other Python modules), this workshop provides a practical hands-on starting point by focusing on ONLY the necessary statistical concepts needed without getting into the mathematical details. Once the foundational concepts have been covered the workshop takes a use case based approach to get, clean, analyze, visualize and predict from multiple data sets. The students develop programs to go through the analytics process by using Linear Regression, Time Series Analysis and Logistic Regression. The end goal is to get them ready to take the next step of their journey into Machine Learning.

Intended Audience

This workshop is intended for anyone with Python skills and the desire to build knowledge and skills related to leveraging data tools to start their journey into Data Analytics.

Objectives

After completing this course, the student will be able to:
- Describe the landscape of Data Analytics
- Describe the role of Pandas in Data Analytics
- Use Pandas to load and prepare data for analysis
- Use Pandas for Linear Regression and prediction
- Use Pandas for Time Series Analysis
- Use Pandas for Logistic Regression and prediction

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Data Automation Workshop using Python
- Prerequisite: Python programming skills
- Required Equipment: Students need a laptop with Python, Notepad ++
- Required Equipment: Students need privileges to install Python modules

Outline

1. Landscape of Analytics and ML
   1.1 What is the Data trying to tell me?
   1.2 Why Analytics? Why Now?
   1.3 What is Machine Learning?
   1.4 What knowledge and skills?
   1.5 Get started with Pandas
   1.6 Process flow for Analytics and ML
   Exercise: Pandas for Data Analytics

2. Statistical Analysis without the Math
   2.1 Data Exploration
   2.2 Hypothesis Testing
   2.3 Inference
   2.4 Data Visualization
   2.5 Predictive and Prescriptive Techniques
   Exercise: Explore Data using Pandas
   Exercise: Explore Data using PowerBI

3. Linear Regression using Pandas
   3.1 Linear Regression without the Math
   3.2 Why and When of Linear Regression

4. Time Series Analysis using Pandas
   4.1 Time Series Analysis without the Math
   4.2 Why and When of Time Series Analysis
   4.3 Get, Clean, Analyze, Visualize, Predict
   4.4 Types of Time Series
   4.5 Types of Models
   Exercise: Use Case: Build Time Series Model 1
   Exercise: Use Case: Build Time Series Model 2

5. Logistic Regression using Pandas
   5.1 Logistic Regression without the Math
   5.2 Why and When of Logistic Regression
   5.3 Get, Clean, Analyze, Visualize, Predict
   Exercise: Use Case: Build LogisticR Model 1
   Exercise: Use Case: Build LogisticR Model 2

Objectives

After completing this course, the student will be able to:
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- Use Pandas to load and prepare data for analysis
- Use Pandas for Linear Regression and prediction
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- Use Pandas for Logistic Regression and prediction

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Intended Audience

This workshop is intended for anyone with Python skills and the desire to build knowledge and skills related to leveraging data tools to start their journey into Data Analytics.

Objectives

After completing this course, the student will be able to:
- Describe the landscape of Data Analytics
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What You Can Expect

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This workshop is intended for anyone with Python skills and the desire to build knowledge and skills related to leveraging data tools to start their journey into Data Analytics.

Objectives

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- Use Pandas for Time Series Analysis
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What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Data Automation Workshop using Python
- Prerequisite: Python programming skills
- Required Equipment: Students need a laptop with Python, Notepad ++
- Required Equipment: Students need privileges to install Python modules

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Intended Audience

This workshop is intended for anyone with Python skills and the desire to build knowledge and skills related to leveraging data tools to start their journey into Data Analytics.

Objectives

After completing this course, the student will be able to:
- Describe the landscape of Data Analytics
- Describe the role of Pandas in Data Analytics
- Use Pandas to load and prepare data for analysis
- Use Pandas for Linear Regression and prediction
- Use Pandas for Time Series Analysis
- Use Pandas for Logistic Regression and prediction

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Data Automation Workshop using Python
- Prerequisite: Python programming skills
- Required Equipment: Students need a laptop with Python, Notepad ++
- Required Equipment: Students need privileges to install Python modules

The Analytics Workshop is designed for individuals who are familiar with Python and want to start their journey into the world of Data Analytics. By using hands-on, lab-based programming exercises (using Python, Pandas, Jupyter Notebooks and other Python modules), this workshop provides a practical hands-on starting point by focusing on ONLY the necessary statistical concepts needed without getting into the mathematical details. Once the foundational concepts have been covered the workshop takes a use case based approach to get, clean, analyze, visualize and predict from multiple data sets. The students develop programs to go through the analytics process by using Linear Regression, Time Series Analysis and Logistic Regression. The end goal is to get them ready to take the next step of their journey into Machine Learning.
Machine Learning Workshop

Machine Learning (ML) aspects of Artificial Intelligence (AI) is revolutionizing all aspects of the computer industry. ML use cases like speech and image recognition have already had an impact on many industries. The telecom industry is different. The Machine Learning Workshop provides a detailed introduction to AI from a telecom perspective. AI is explored from a definition and underlying technology perspective. It starts with an introduction to AI models. The course then moves to an exploration of data selection, then to the details of building Machine Learning models and Deep Learning models based on telecom-specific data. The key concepts are presented using hands-on activities that include analyzing data and using a Machine Learning model in Python and Pandas. Hands-on Exercises are based on Pandas and Splunk.

Intended Audience

This workshop is intended for anyone with Python skills and the desire to build knowledge and skills related to leveraging data tools to start their journey into Data Analytics. It follows the Part 1 of the Workshop series.

Objectives

After completing this course, the student will be able to:
- Define AI terms: Neural Network, ML, Deep Learning
- List key examples of neural networks
- Describe model training, testing and deployment
- Describe types of input data
- List key Machine Learning tools
- Build a basic Machine Learning model using Python
- Build a basic Machine Learning model using a cloud-based Service

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Data Automation Workshop using Python
- Prerequisite: Analytics Workshop
- Required Equipment: Students will need a laptop with Python, Notepad ++
- Required Equipment: Students will need privileges to install Python modules

Outline

1. AI Defined
   1.1 What is AI?
   1.2 What is ML?
   1.3 What is Deep Learning?
   1.4 AI – An End User View
   
   Exercise: Use Case: Inference and AI Model
   Exercise: Use Case: Cloud-based Service Use Case

2. ML Models Defined
   2.1 What is an ANN?
   2.2 Basics of ML Model Design
   2.3 Types of Learning
   2.4 ML Models
   
   Exercise: Use Case: Types of Supervised Learning and Neural Networks
   Exercise: Use Case: Cloud-based Service Use Case

3. ML Lifecycle
   3.1 Building and Framing the ML Model
   3.2 Data Gathering and Preparation

4. ML Data Preparation
   4.1 Types of Data
   4.2 Data Selection and Process Flow

   Exercise: Use Case: Prepare Data for ML Model Creation
   Exercise: Use Case: Cloud-based Service Use Case

5. ML Model Creation and Training
   5.1 ML Model Layer Details
   5.2 Neurons and Activation Functions
   5.3 Defining Hyperparameters
   5.4 Analyzing Results
   5.5 ML Development Libraries

   Exercise: Use Case: Build and Train the ML Model
   Exercise: Use Case: Cloud-based Service Use Case

View Curriculum
Deep Learning Concepts Workshop

Deep Learning has taken the concepts of Machine Learning and extended them to support more complex data analysis and predictions. This course provides a hands-on introduction to the basic concepts of Deep Learning from a telecom perspective. Deep Learning is explored from a definition and underlying technology perspective. It starts with an introduction to Deep Learning models. The course then moves to an exploration of the data selection and analysis. The course then moves into the details of building a number of Deep Learning models based on telecom specific data. The key concepts are presented using hands on activities that include analyzing data, using a Deep Learning model in python and using a GUI based tool.

Intended Audience
For personnel involved in product management, marketing, planning, design, engineering, and operating wireless (4G, 5G) and wireline access networks who need a technical introduction to AI

Objectives
After completing this course, the student will be able to:

- List key types of neural networks and compare them
- Define key Data Selection processes like Eigen decomposition
- Prepare Data for training a Deep Learning Model
- Describe a Convolutional Neural Network model and its uses
- Build a CNN model
- Describe a Recurrent Neural Network model and its uses
- Build a RNN model
- Analyze an Unsupervised Learning Model and describe the steps involved

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: AI Tools and Technology

Outline

1. Overview of Deep Learning Models
   1.1 Convolutional Neural Networks
   1.2 Recurrent Neural Networks
   1.3 Auto Encoder
   1.4 Generative adversarial networks
   1.5 Model Training vs. Model Deployment
      Exercise: Use a number of Deep Learning models

2. Data Selection
   2.1 Data Selection and Analysis
   2.2 Intuitive description of n-dimensional vector space
   2.3 Eigen decomposition
   2.4 Eigen values, eigen vectors
   2.5 Decomposition
   2.6 Principle Component Analysis
      Exercise: Prepare Data for a Deep Learning Model

3. Convolutional Neural Network (CNN) Lab
   3.1 Basic CNN Example
   3.2 CNN Model Details
   3.3 CNN Model Use Cases
      Exercise: Build a CNN Model

4. Recurrent Neural Network (RNN) Lab
   4.1 Basic RNN Example
   4.2 RNN Model Design
   4.3 RNN Model Use Cases
      Exercise: Build a RNN Model

5. Unsupervised Learning Lab
   5.1 Basic Unsupervised Learning Example
   5.2 Specific Unsupervised Learning Models
   5.3 Unsupervised Learning Data Analysis
      Exercise: Build an Unsupervised Learning Model

View Curriculum
Data Automation Mentoring Program

The Data Automation Mentoring is designed for non-programmers who want to create programs in Python to help them automate some of their mundane daily tasks related to gathering and analyzing data. By using hands-on, lab-based programming exercises and a mix of live sessions and programming assignments, it provides an opportunity to the student to define and develop a Python program based on a practical and relevant use case. [Live Session: 1/2 day every week], [One-on-One Mentoring: 1 hour each week], [Self-Study: Python program development, approximately 6 hours average each week]

Intended Audience

This workshop is intended for anyone (non-programmers) who wants to build knowledge and skills related to leveraging data tools to be more productive.

Objectives

After completing this course, the student will be able to:

■ Analyze a problem and design step-by-step ways to automate the task at hand
■ Learn how to manage data in different forms of data structures to load and manipulate data
■ How to use key control structures to manage the process flow
■ Implement solutions based on string manipulation, regular expression processing and loops
■ Implement a data processing exercise using control and data structures including file operations
■ Implement text file and Excel file handling for Input/Output processing
■ Learn how to automate data collection through APIs
■ Python is used as the programming language for all exercises and lab-work

What You Can Expect

■ Self-Paced Duration: 32 HOUR
■ Expert-Led Live Duration: 40 HOUR
■ Total Program Duration: 9 WEEK
■ Prerequisite: Basic knowledge of Excel
■ Required Equipment: Students will need a laptop with MS-Excel and Python

Outline

1. Fundamentals of PYTHON 1
   1.1 Create and run a program
   1.2 int, str, float, print()
   1.3 Import - os, sys
   Exercise: Program Development Assignment

2. Fundamentals of PYTHON 2
   2.1 File operations
   2.2 for, if/elif/else, lists, sys.argv
   2.3 try, except
   Exercise: Program Development Assignment

3. OPENPYXL
   3.1 pip install, while
   3.2 xlsx - open, create, read, write, save
   3.3 chart, sys.argv, tkinter
   Exercise: Program Development Assignment

4. PANDAS
   4.1 pandas dataframe
   4.2 load dataframe, output to xlsx
   4.3 add, drop, columns, rows, analysis
   Exercise: Program Development Assignment

5. Participant USE CASE - PART 1
   5.1 Designing simple, maintainable scripts
   5.2 Writing pseudo-code, functions, logical steps

6. Participant USE CASE - PART 2
   6.1 Types of inputs
   6.2 File-based, URL-based, API-based, SQL-based
   6.3 Example of invoking an API
   Exercise: Program Development Assignment

7. Participant USE CASE - PART 3
   7.1 Analysis using python and/or pandas
   7.2 Package specific implementations
   7.3 Pros and Cons of approaches
   Exercise: Program Development Assignment

8. Participant USE CASE - PART 4
   8.1 Output the analysis from the USE CASE
   8.2 Output format
   8.3 Output visualizations
   Exercise: Program Development Assignment

9. Participant USE CASE - Final Completion
   9.1 Participant USE CASE submission
   9.2 Participant USE CASE presentation
   9.3 Participant USE CASE demonstration
   9.4 Feedback and Wrap-up

View Curriculum
LTE and VoLTE
LTE and VoLTE

SELF-PACED
- Exploring LTE: Architecture and Interfaces
- Exploring LTE: Signaling and Operations - Part I
- Exploring LTE: Signaling and Operations - Part II
- Exploring VoLTE: Architecture and Interfaces
- Exploring VoLTE: KPIs and Error Codes

TECH PRIMER
- Licensed-Assisted Access (LAA)
- Overview of CBRS

LTE RF Optimization
- Part II - DL and UL Throughput
- Part IV - Carrier Aggregation and Load Balancing

LTE RF Optimization
- Part III - Mobility and Inter-RAT

VoLTE Troubleshooting Workshop

VoLTE RAN Performance Workshop

RF Design Workshop Part I - LTE
- LTE

RF Design Workshop Part II - VoLTE and Small Cells

Introduction to VoLTE

Welcome to LTE

Overview of OFDM

Overview of IPv6 in LTE Networks

VoLTE Overview

Multiple Antenna Techniques

Overview of LTE Overview

LTE RF Optimization Part I - Coverage and Accessibility

VoLTE Overview
LTE and VoLTE

We help our customers tackle technology, faster.
Curriculums include:

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**BLENDDED**
- Introduction to VoLTE

**EXPERT-LED LIVE**
- Licensed-Assisted Access (LAA)
- Overview of CBRS
- RF Design Workshop Part I - LTE
- RF Design Workshop Part II - VoLTE and Small Cells
- LTE RF Optimization Part I - Coverage and Accessibility
- LTE RF Optimization Part II - DL and UL Throughput
- LTE RF Optimization Part III - Mobility and Inter-RAT
- LTE RF Optimization Part IV - Carrier Aggregation and Load Balancing
- VoLTE Troubleshooting Workshop
- VoLTE RAN Performance Workshop

**SELF-PACED**
- Exploring LTE: Architecture and Interfaces
- Exploring LTE: Signaling and Operations - Part I
- Exploring LTE: Signaling and Operations - Part II
- Exploring VoLTE: Architecture and Interfaces
- Exploring VoLTE: Signaling and Operations
- Exploring VoLTE: KPIs and Error Codes
- LTE Air Interface Signaling Overview
- LTE Overview
- Multiple Antenna Techniques
- Overview of OFDM
- Overview of IPv6 in LTE Networks
- VoLTE Overview
- Welcome to LTE
Exploring LTE: Architecture and Interfaces

Long Term Evolution (LTE) is explicitly designed to deliver high-speed, high quality services to mobile subscribers. In order to achieve this, the LTE network architecture introduces a number of new network nodes and interfaces to implement the necessary functionality and manage the exchange of packets between mobile devices and external packet data networks. This self-paced eLearning class discusses the overarching goals of LTE networks and then defines the unique network functions needed to achieve those goals. The course then describes the key interfaces between these functions, with particular emphasis on the LTE air interface, as well as the underlying protocols carried over these interfaces. Frequent interactions are used to ensure student comprehension of the essential technologies used in all LTE networks.

Outline

1. What is LTE?
   1.1 4G LTE
   1.2 Packet data networks

2. LTE Network Nodes and Functions
   2.1 E-UTRAN and EPC
   2.2 eNodeB
   2.3 MME
   2.4 HSS
   2.5 S-GW
   2.6 P-GW

3. Other Network Functions
   3.1 PCC
   3.2 DNS
   3.3 DRA
   3.4 NAT/PAT
   3.5 Firewalls
   3.6 MSP
   3.7 OSS

4. LTE Network Interfaces and Protocols
   4.1 Internet Protocol (IP)
   4.2 S1-MME and S1-U
   4.3 S6a
   4.4 S11
   4.5 S5
   4.6 X2

5. EPC Bearers
   5.1 Default bearers
   5.2 Dedicated bearers

6. LTE Air Interface
   6.1 LTE-Uu protocol stack
   6.2 OFDMA and SC-FDMA
   6.3 OFDM and Cyclic Prefix
   6.4 Air interface physical layer
   6.5 Air interface physical channels
   6.6 Reference signals
   6.7 MIMO and diversity
   6.8 Basic traffic operations

Intended Audience

This course is intended for a technical audience looking for a detailed understanding of the important nodes, functions, and interfaces found in a typical LTE network.

Objectives

After completing this course, the student will be able to:

- Discuss the rationale behind the 4G LTE network architecture
- Describe the critical network functions required in every LTE network
- Describe nodes and functions typically found in large commercial wireless networks
- Identify the key interfaces between LTE nodes and the protocols carried over each interface
- Define EPS bearers and describe their role in supporting user services
- Explain the structure and functions of the LTE air interface

What You Can Expect

- Self-Paced Duration: 1 HOUR
- Prerequisite: Welcome to LTE (eLearning)
- Prerequisite: LTE-SAE Evolved Packet Core (EPC) Overview (eLearning)
Exploring LTE: Signaling and Operations – Part I

The Long Term Evolution (LTE) network is designed to deliver services and content to mobile subscribers quickly and with high quality. To do this, the various elements within the network communicate with each other and with the mobile device using well-defined protocols and procedures to accomplish the tasks and operations required. This eLearning module is part one of the two-module package. Together, these two modules describe each of the key LTE operations, starting with the mobile’s initial access to the system, followed by the steps needed to connect users to their services and content, and continuing with the challenges associated with maintaining the connections as the user moves through the network. The course concludes with a discussion of the mobile’s idle mode activities and the low-level operations needed to maintain the radio link.

Intended Audience
This course is intended for a technical audience looking for an in-depth understanding of the important signaling sequences and detailed operations used in a typical LTE network.

Objectives
After completing this course, the student will be able to:
- Describe how a UE accesses the LTE network on initial power-up
- Explain the steps involved in attaching to the network and establishing PDN connections

What You Can Expect
- Self-Paced Duration: 1.5 HOUR
- Prerequisite: Exploring LTE: Architecture and Interfaces (eLearning)

Outline

1. RRC Connections
   1.1 Acquisition and downlink synch
   1.2 PCI and PCI planning
   1.3 MIB and SIBs
   1.4 RSRP, RSRQ, and SINR
   1.5 Cell selection and reselection
   1.6 Uplink synchronization
   1.7 PRACH configuration
   1.8 Preambles and RSIs
   1.9 RRC Connection setup

2. Network Attach
   2.1 Network Attach signaling

3. PDN Connections
   3.1 PDN connectivity
   3.2 IP addressing
   3.3 GTP tunneling
Intended Audience
This course is intended for a technical audience looking for an in-depth understanding of the important signaling sequences and detailed operations used in a typical LTE network.

Objectives
After completing this course, the student will be able to:
- Explain how user traffic is exchanged over the air interface under varying radio conditions
- Define the physical layer functions needed to maintain an active radio connection
- Discuss methods to track mobile location and maintain connection as it moves through a network
- Describe the tasks the mobile must perform while in idle state

What You Can Expect
- Self-Paced Duration: 1.5 HOUR
- Prerequisite: Exploring LTE: Architecture and Interfaces (eLearning)
- Prerequisite: Exploring LTE: Signaling and Operations – Part I (eLearning)

Outline
1. UL and DL Traffic Operations
   1.1 QCI and QoS parameters
   1.2 PCP
   1.3 CQI, RI, and PMI
   1.4 Downlink packet processing
   1.5 Uplink packet processing
   1.6 Error detection and recovery
2. Physical Layer Operations
   2.1 Timing alignment
   2.2 Power control
3. Mobility and Handover
   3.1 Handover measurements and events
   3.2 X2-based handover signaling
   3.3 S1-based handover signaling
4. Idle Mode Operations
   4.1 Paging
   4.2 Tracking area updates
Exploring VoLTE: Architecture and Interfaces

Long Term Evolution (LTE) network is optimized for delivering high-speed packet-oriented content and services to a large number of mobile users. However, some services, such as conversational voice over IP (VoIP), require special treatment in order to minimize end-to-end delay and provide a satisfactory user experience. The wireless industry has adopted the IP Multimedia Subsystem (IMS) architecture to implement real-time and multimedia services to LTE subscribers; Voice over LTE, or VoLTE, is the term given to voice services delivered over LTE. This self-paced eLearning course describes the network requirements for VoLTE and describes the IMS network components and interfaces needed to implement VoLTE and other IMS-based services. The course also discusses how IMS and LTE interwork with non-IMS networks in order to support worldwide calling services.

Intended Audience

This course is intended for a technical audience looking for an in-depth understanding of the important nodes, functions, and interfaces found in a typical VoLTE/IMS network.

Objectives

After completing this course, the student will be able to:

■ Discuss the motivations and requirements for VoLTE and IMS
■ Define the key nodes and functions needed in a typical IMS network
■ Identify key interfaces between IMS nodes and define the protocols carried over each interface
■ Illustrate the paths control signaling and voice media take through the LTE and IMS networks

What You Can Expect

■ Self-Paced Duration: 1 HOUR
■ Prerequisite: Exploring LTE: Architecture and Interfaces (eLearning)
■ Prerequisite: Exploring LTE: Signaling and Operations (eLearning)

Outline

1. What is VoLTE?
   1.1 IR.92
   1.2 VoIP and QoS
   1.3 IMS

2. IMS Network Nodes and Functions
   2.1 P-CSCF, I-CSCF, and S-CSCF
   2.2 ENUM and IMS HSS
   2.3 TAS
   2.4 SCC-AS and BGCF
   2.5 MGCF, MGW, and SGW
   2.6 MRFC and MRFP

3. IMS Network Interfaces
   3.1 Rx
   3.2 Cx and Sh
   3.3 ISC
   3.4 Media interfaces

4. VoLTE Protocols
   4.1 SIP and SDP
   4.2 Diameter
   4.3 RTP and RTCP
   4.4 Megaco (H.248)
Intended Audience

This course is intended for a technical audience looking for an in-depth understanding of the important signaling sequences and detailed operations used in a typical VoLTE network.

Objectives

After completing this course, the student will be able to:

■ Describe the steps involved with registering with the IMS network
■ Explain how VoLTE devices initiate and receive calls with each other
■ Discuss the methods used to interwork with non-VoLTE networks
■ Explain how supplementary services are implemented in VoLTE
■ Describe the special requirements and operations needed for emergency calls
■ Describe the air interface optimizations defined to improve VoLTE performance

What You Can Expect

■ Self-Paced Duration: 1.5 HOUR
■ Prerequisite: Exploring VoLTE: Architecture and Interfaces (eLearning)
■ Prerequisite: Exploring LTE: Signaling and Operations (eLearning)

Outline

1. VoLTE Registration
   1.1 P-CSCF and I-CSCF discovery
   1.2 S-CSCF selection
   1.3 Registration signaling
   1.4 De-registration signaling

2. VoLTE Call Origination
   2.1 Origination signaling
   2.2 Originating services and TAS
   2.3 Called party routing
   2.4 Preconditions

3. VoLTE Call Termination
   3.1 Termination signaling
   3.2 Terminating services and TAS
   3.3 SDP negotiation and alerting
   3.4 Dedicated bearer setup

4. VoLTE Interworking
   4.1 VoLTE-to-PSTN/3G signaling
   4.2 PSTN/3G-to-VoLTE signaling

5. Supplementary Services
   5.1 Telephony Application Server (TAS)
   5.2 Voicemail and MWI
   5.3 SMS and messaging

6. Emergency Calling
   6.1 Emergency numbers and sos APN
   6.2 E-CSCF selection and routing

7. Air Interface Enhancements
   7.1 Semi-Persistent Scheduling (SPS)
   7.2 TTI bundling
   7.3 RoHC
Exploring VoLTE: KPIs and Error Codes

Evaluating the performance of Long Term Evolution (LTE) and IP Multimedia Subsystem (IMS) networks can be challenging, given the complexity of the networks and the wide variety of services carried over them. The wireless industry has adopted a common set of Key Performance Indicators (KPIs) for LTE and VoLTE, allowing operators to develop a consistent set of monitoring tools independent of the specific vendors involved. This self-paced eLearning course defines these KPIs, discusses typical target values for each one, and describes typical failure scenarios for each of the metrics. In addition, the signaling protocols used in VoLTE operations can provide additional insights into certain failures, through the use of error codes and cause codes included in the messages.

Intended Audience
This course is intended for a technical audience looking for an overview of the KPIs typically used to evaluate LTE and VoLTE networks, along with the more common error codes encountered in VoLTE signaling.

Objectives
After completing this course, the student will be able to:
- Define the standard KPIs used to evaluate LTE and VoLTE performance
- Explain the common response and result codes reported in SIP and Diameter signaling messages

What You Can Expect
- Self-Paced Duration: 0.5 HOUR
- Prerequisite: Exploring LTE: Signaling and Operations (eLearning)
- Prerequisite: Exploring VoLTE: Signaling and Operations (eLearning)

Outline

1. LTE KPIs
   1.1 Availability
   1.2 Accessibility
   1.3 Retainability
   1.4 Mobility
   1.5 Throughput

2. VoLTE KPIs
   2.1 Call Accessibility
   2.2 Call Retainability
   2.3 Call Mobility
   2.4 Mean Opinion Score (MOS)

3. SIP Error Codes
   3.1 Response codes

4. Diameter Error Codes
   4.1 Result codes
LTE Air Interface Signaling Overview

Long Term Evolution (LTE) is a leading contender for next generation broadband wireless networks, providing an evolution path for a variety of 3G wireless networks, such as UMTS and 1xEV-DO. LTE offers significantly higher packet data rates, enabling advanced multimedia applications and high-speed Internet access. This course takes a look at the LTE air interface and Non-Access Stratum (NAS) signaling operations used to establish and maintain LTE calls. The key LTE network components and interfaces are described, and then the steps involved in establishing and managing data calls are illustrated, highlighting the roles of each component and the flow of signaling and data across the network. By the conclusion of this course, the student will have a deeper understanding of how the UE and the network work together to deliver services to LTE subscribers.

Intended Audience
This course provides an overview of LTE signaling operations, and is targeted for a broad audience for a quick reference to LTE operations. This includes those in engineering, operations, and product sales/marketing.

Objectives
After completing this course, the student will be able to:

- Sketch the key components of a typical LTE network and the interfaces between them
- List the key channels of DL and UL in LTE
- Provide an overview of call setup and related signaling in LTE
- Walk through the steps involved in a network attach
- Discuss the establishment of EPS bearers
- Explain how QoS requirements are managed in LTE
- Summarize the cell selection and reselection processes for idle UEs
- Illustrate how active connections are maintained during handovers

What You Can Expect
- Self-Paced Duration: 3 HOUR
- Prerequisite: LTE Overview (eLearning)

Outline

1. LTE Network Architecture Overview
   1.1 E-UTRAN architecture
   1.2 EPC (MME, S-GW, P-GW, HSS)
2. LTE Air Interface Signaling Basics
   2.1 LTE physical layer
3. System Acquisition
   3.1 Power-up acquisition
4. Network Attachment and Default Bearer
   4.1 Attachment steps
   4.2 Default bearer setup
5. QoS and Dedicated Bearers
   5.1 QoS classes
   5.2 Dedicated EPS bearers
6. Uplink and Downlink Traffic
   6.1 Downlink traffic operations
   6.2 Uplink traffic operations
7. Idle Mode
   7.1 Idle mode defined
   7.2 Cell reselection
   7.3 Tracking and paging
8. Handover
   8.1 Handover types
   8.2 Measurement
   8.3 Handover stages
9. Summary
   9.1 Put It All Together
   9.2 Assess the knowledge of the participant based on the objectives of the course
LTE Overview

Long Term Evolution (LTE) is one of the choices for next generation broadband wireless networks and is defined by the 3GPP standards as an evolution to a variety of 3G wireless networks such as UMTS and 1xEV-DO. Its high data rates enable advanced multimedia applications. This course offers a quick and concise overview of LTE networks and the OFDM-based air interface. The LTE network architecture, network interfaces and protocols, air interface and mobility aspects are covered to provide an end-to-end view of the network. A high-level glimpse into the life of an LTE User Equipment (UE) is provided by walking through stages from power-up all the way to setting up an IP address and exchanging traffic. By the end of this course, the student will understand what LTE offers, its network architecture, how it works, and potential applications and services.

Intended Audience
This course is an end-to-end overview of LTE networks, and is targeted for a broad audience. This includes those in design, test, sales, marketing, system engineering and deployment groups.

Objectives
After completing this course, the student will be able to:

- Describe the state of wireless networks and trends for next generation wireless networks
- Sketch the System Architecture Evolution (SAE) for LTE and its interfaces
- Describe OFDM concepts and how it is used in LTE
- Define the key features of the LTE air interface
- Walk through the mobile device operations from power-up to service setup
- Explain how uplink and downlink traffic are handled in LTE networks
- Walk through a high level service flow setup on an end-to-end basis
- Explain deployment scenarios of LTE networks

What You Can Expect
- Self-Paced Duration: 3.5 HOUR

Outline

1. Setting the Stage
   1.1 Introduction to LTE

2. LTE Network Architecture
   2.1 Evolved Packet Core (EPC)
   2.2 E-UTRAN - eNodeB
   2.3 Network interfaces and protocol stacks

3. LTE Air Interface
   3.1 OFDM/OFDMA radio concepts
   3.2 SC-FDMA radio concepts
   3.3 Radio transmission frame structures
   3.4 Transport to physical channel mapping

4. LTE UE Operations
   4.1 System acquisition
   4.2 Idle mode operations
   4.3 Initial access procedures

4.4 QoS
4.5 Registration and traffic

5. LTE Traffic Handling
   5.1 Downlink traffic handling
   5.2 Uplink traffic handling

6. LTE Mobility
   6.1 Idle mode mobility
   6.2 Active mode mobility / handover

7. Deployment
   7.1 Typical LTE evolutionary path

8. Summary
   8.1 Put It All Together
   8.2 Assess the knowledge of the participant based on the objectives of the course

What You Can Expect
- Self-Paced Duration: 3.5 HOUR
Multiple Antenna Techniques

Advanced multiple antenna technologies enable emerging 4G cellular technologies to achieve superior data rates over the air interface (e.g., in excess of 100 Mbps). While 4G networks utilize an efficient multiple access technique called Orthogonal Frequency Division Multiple Access (OFDMA), OFDMA on its own cannot deliver the expected superior throughput in 4G systems. Multiple antenna techniques play a critical role in increasing spectral efficiency. This course provides fundamental knowledge of numerous multiple antenna techniques that will be an integral part of emerging radio access standards. The antenna basics are explained, along with typical antenna configurations in commercial cellular deployments. Major antenna techniques are covered in the course, providing a strong foundation for advanced antenna technologies.

Intended Audience

This course is intended for those seeking a fundamental understanding of how multiple antenna techniques work. This includes those in a systems engineering, sales engineering, network engineering, or verification role.

Objectives

After completing this course, the student will be able to:

■ Outline key benefits and challenges of multiple antenna techniques
■ Provide examples of various types of multiple antenna techniques
■ Explain transmit and receive diversity techniques such as STC and antenna grouping
■ Contrast a switched-beam system with an adaptive beamforming technique
■ Describe MIMO spatial multiplexing techniques
■ Discuss the implementation of SDMA
■ Give examples of multiple antenna techniques defined in emerging 4G cellular networks

What You Can Expect

■ Self-Paced Duration: 3 HOUR

Outline

1. Antenna Basics
   1.1 Antenna Characteristics
   1.2 Antennas in commercial deployments
   1.3 Motivation for MIMO

2. Transmit and Receive Diversity Techniques
   2.1 Introduction to Diversity
   2.2 Receive Diversity Techniques
   2.3 Transmit Diversity Techniques

3. Beamforming Techniques
   3.1 Basics of Beamforming
   3.2 Receive and Transmit Beamforming
   3.3 Advanced Beamforming techniques

4. MIMO - Spatial Multiplexing
   4.1 Basics of spatial multiplexing
   4.2 MIMO and channel coding
   4.3 Advanced MIMO Techniques

Putting It All Together

View Curriculum
Orthogonal Frequency Division Multiplexing (OFDM) is a transmission technique used to achieve very high data rates. OFDM is the technology of choice for all major wireless systems including Wireless LAN – 802.11, WiMAX – 802.16, digital audio/video broadcast systems, and the air interface evolution of 3G Wireless systems based on 3GPP and 3GPP2. OFDM facilitates higher data rates over a wireless medium, which is very exciting to wireless operators who are eager to deploy multimedia rich Internet content over a wireless medium with seamless access anywhere, anytime. This course describes key OFDM concepts and terminology. It explains the challenges of radio propagation and describes how OFDM overcomes these challenges to offer high data rates in a spectrally efficient manner, and steps through the key OFDM operations in an end-to-end transmission.

Outline

1. Introduction
   1.1 Evolution of radio technologies
   1.2 Concepts of FDMA, TDMA, CDMA
   1.3 Need for OFDM for high data rates

2. Principles of OFDM
   2.1 Key attributes of OFDM
   2.2 Frequency domain orthogonality
   2.3 Time and frequency domain views

3. OFDM Basics
   3.1 Carrier and subcarrier
   3.2 Modulation and OFDM symbol
   3.3 Subcarrier spacing
   3.4 Guard period and cyclic prefix

4. Radio Propagation
   4.1 Multipath and doppler shift
   4.2 Inter Symbol Interference (ISI)
   4.3 Guard Time

5. Fourier Transform
   5.1 Motivation for using Fourier Transforms in OFDM systems
   5.2 Concept of Fourier Transform
   5.3 Discrete Fourier Transform (DFT)
   5.4 Fast Fourier Transform (FFT)
   5.5 Implementation

6. End-to-End Transmission
   6.1 Transmitter and receiver components
   6.2 OFDM operations

7. Summary
   7.1 Put It All Together
   7.2 Assess the knowledge of the participant based on the objectives of the course
Overview of IPv6 in LTE Networks

Long Term Evolution (LTE) is universally accepted as the next generation broadband wireless system based on an All-IP network. Each LTE device would need at least one IP address to communicate and obtain services like web browsing, machine-to-machine communication, voice and video services, SMS, etc. As the number of IP connected nodes continue to grow, the current IPv4-NAT architecture no longer suffices and we must consider a transition to IPv6 protocol. This eLearning course explores the IPv6 protocol, its features and capabilities. It explains IPv6 address format, assignment of IPv6 address to LTE devices, dual-stack IPv4v6 addressing to facilitate smooth transition, and IPv4-IPv6 interworking. In conclusion, the student will understand the use of IPv6 addresses and IPv6 operations in LTE networks.

Intended Audience

This course is an overview of IPv6 addressing formats and IPv6 assignment operation, and is targeted for a broad audience. This includes those in planning, provisioning, operations, and end-to-end service deployment groups.

Objectives

After completing this course, the student will be able to:

- Sketch LTE-EPC network architecture and identify the role of IPv6
- Analyze the limitations of IPv4 addresses
- List the key aspects of IPv6
- Sketch the IPv6 addressing architecture and addressing formats
- Discuss different UE IP address allocation schemes in LTE
- Describe the use of dual stack IPv4/IPv6 in LTE Networks
- Describe some IPv4 and IPv6 interworking scenarios
- Explain IPv6 address assignment scenarios of LTE networks

What You Can Expect

- Self-Paced Duration: 2 HOUR

Outline

1. Setting the Stage
   1.1 LTE-EPC network architecture
   1.2 PDN connections
   1.3 IP address assignment in LTE

2. IPv4 in Wireless Networks
   2.1 IPv4 address formats
   2.2 Use of public and private addresses
   2.3 Mobility support – GTP and mobile IP
   2.4 Limitations of IPv4

3. IPv6 Essentials
   3.1 Key aspects of IPv6
   3.2 IPv6 header description
   3.3 IPv6 addressing

4. IPv6 Assignment in LTE Networks
   4.1 Default bearer setup operation
   4.2 IPv6 address allocation
   4.3 Role of NAS signaling
   4.4 Assignment of dual-stack IPv4/IPv6 addresses

5. IPv4/IPv6 Transition Mechanisms
   5.1 Dual stack addressing
   5.2 Tunnels
   5.3 Translators

6. IPv6 Deployment in LTE Networks
   6.1 Dual-stack connectivity
   6.2 IPv6 migration scenarios
   6.3 Put It All Together
   6.4 Assess the knowledge of the participant based on the objectives of the course
VoLTE Overview

The LTE Evolved Packet Core (EPC) is an evolution of the 3GPP system architecture with the vision of an all-IP network finally realized. EPC in conjunction with IP Multimedia Subsystem (IMS) delivers various services such as VoIP, SMS, Video call, Picture share, IM and Presence. EPC and IMS support interworking with the existing 2G/3G wireless networks as well as PSTN to facilitate smooth migration, seamless mobility and service continuity across these networks. This eLearning module provides an overview of supporting voice services using LTE, which is known as Voice over LTE (VoLTE). LTE-EPC, IMS, and the PCC are discussed as the building blocks for VoLTE. The pre-call operations such as connectivity with the IMS network and IMS registration are explained along with VoLTE call setup and configuration.

Intended Audience

This course is an overview of Voice over LTE, and is targeted for a broad audience. This audience includes those in planning, Integration, operations, and end-to-end service deployment groups.

Objectives

After completing this course, the student will be able to:

■ List various solutions for delivering voice in LTE networks
■ Describe the role of LTE-EPC, PCC, and IMS in VoLTE
■ Specify the roles of key IMS and PCC nodes
■ Sketch inter-connectivity of LTE-EPC, IMS, and PCC nodes to deliver an end-to-end IMS call
■ Summarize main steps of pre-call operations such as IMS registration
■ Describe the main steps of setting up a VoLTE call
■ Specify how SMS can be supported in LTE

What You Can Expect

■ Self-Paced Duration: 1.5 HOUR
■ Prerequisite: LTE Overview (eLearning)
■ Prerequisite: Overview of IMS (eLearning)

Outline

1. Overview of EPS
   1.1 Supporting voice services in LTE
   1.2 Overall network architecture (EPS, IMS, PCC)
   1.3 Initial attach
   1.4 Default vs. dedicated EPS bearers
   1.5 Connectivity with IMS APN

2. Connectivity Among EPS, IMS, and PCC
   2.1 Overview of IMS elements
   2.2 Overview of PCC elements
   2.3 QoS model in LTE
   2.4 Connectivity of IMS, LTE-EPC & PCC

3. Pre-Call IMS Functions for VoLTE
   3.1 PDN connection to IMS
   3.2 P-CSCF discovery
   3.3 IMS registration

4. VoLTE Call Setup
   4.1 Overall steps for an all-IP call
   4.2 PCC-IMS interactions
   4.3 Dedicated bearer setup

5. VoLTE-Scenarios
   5.1 LTE-PSTN interworking and role of IMS
   5.2 Overview of Single Radio Voice Call Continuity (SRVCC)
   5.3 Supporting SMS in LTE

6. Summary

7. Put It All Together
   7.1 Assess the knowledge of the participant based on the objectives of the course

View Curriculum
Welcome to LTE

Long Term Evolution (LTE) is one of the choices for next generation broadband wireless networks and is defined by the 3GPP standards as an evolution to a variety of 3G wireless networks, including both UMTS and 1xEV-DO; its high data rates enable a wide range of advanced multimedia applications. This eLearning course offers a quick, high-level overview of LTE radio and Evolved Packet Core (EPC) networks. The key characteristics of the LTE air interface, access network and core network are defined, along with a review of the capabilities of the LTE user equipment (UE). The services expected to be supported on LTE networks are summarized, with special emphasis on voice solutions. Finally, important considerations for deploying LTE networks are laid out, including the ability to interwork with existing 3G networks.

Intended Audience

This course is an end-to-end overview of LTE networks and is targeted for a broad audience. This includes those in sales, marketing, deployment, operations, and support groups.

Objectives

After completing this course, the student will be able to:

- Identify the motivations and goals for 4G networks
- Summarize the basic concepts of LTE Air Interface
- Sketch the high-level architectures of the E-UTRAN and EPC
- Describe the different categories of LTE UE
- Walk through a typical LTE call from power-up to service setup to disconnect
- Define the key services expected on LTE networks
- Illustrate the interworking solutions for GSM/UMTS and 1x/1xEV-DO networks
- Explain the important factors to consider when deploying LTE networks

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. Motivations for 4G
   1.1 3G limitations
   1.2 LTE goals and targets
   1.3 4G building blocks
2. LTE Network Architecture
   2.1 LTE architecture goals
   2.2 LTE network components
   2.3 Evolved UTRAN (E-UTRAN)
   2.4 Evolved Packet Core (EPC)
3. LTE Devices
   3.1 Device categories
   3.2 Role of SIM card
4. LTE Air Interface
   4.1 Scalable bandwidth
   4.2 Supported radio bands
5. LTE Services
   5.1 Typical call setup sequence
   5.2 Basic and enhanced services
   5.3 Voice and SMS solutions
   5.4 IP Multimedia Subsystem (IMS)
   5.5 Policy and Charging Control (PCC)
6. LTE Deployment
   6.1 Interworking with GSM/UMTS
   6.2 Interworking with 1x/1xEV-DO
   6.3 Deployment considerations
   6.4 Backhaul options

View Curriculum
Technology Primer: Licensed Assisted Access (LAA)

Exponentially rising data traffic, scarcity of spectrum, and expectations of enhanced user experience are leading operators to explore the use of unlicensed spectrum to carry traffic. 3GPP has defined specific approaches for using the unlicensed spectrum. In one approach, some or all of the traffic is carried by the Wi-Fi network in the unlicensed spectrum. Example mechanisms include Wi-Fi offload and LTE-Wi-Fi Link Aggregation (LWA). In another approach, the traffic is carried by LTE and its evolutionary technologies (e.g., LTE-Advanced) simultaneously on licensed and unlicensed spectrums. Example mechanisms include Licensed Assisted Access (LAA), LTE-Unlicensed (LTE-U), and enhanced LAA (eLAA). This course provides an overview of these mechanisms, a closer look at their key components, and operational similarities and differences between LTE and LAA.

Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations.

Objectives
After completing this course, the student will be able to:
■ Explain the motivation behind the use of unlicensed spectrum
■ Distinguish among Wi-Fi offload, LWA, LTE-U, LAA, and eLAA
■ List benefits of using LTE in unlicensed spectrum instead of Wi-Fi
■ Identify key technology components for LAA, LTE-U, and eLAA
■ Describe mechanisms used by LAA to share the unlicensed spectrum with Wi-Fi networks
■ Summarize how downlink data transfer occurs in LAA
■ Summarize required changes in the UE and the network to support LAA

What You Can Expect
■ Expert-Led Live Duration: 4 HOUR
■ Prerequisite: LTE Overview (eLearning)

Outline
1. LTE in Unlicensed Spectrum
   1.1 Motivation for unlicensed spectrum
   1.2 Evolution of unlicensed LTE
   1.3 LTE-Wi-Fi interworking
   1.4 Wi-Fi offload
   1.5 LWA
   1.6 Carrier aggregation with unlicensed spectrum
   1.7 LTE-U
   1.8 LAA and eLAA
2. Key Technology Components
   2.1 LTE vs. Wi-Fi
   2.2 Unlicensed spectrum: bands and FCC regulations
   2.3 Small Cells
   2.4 Carrier aggregation
   2.5 Spectrum-sharing mechanisms
3. LAA Operations
   3.1 Bearer setup
   3.2 UE capability exchange
   3.3 SCell configuration and activation
   3.4 DL data transfer
   3.5 UE and network changes for LAA

2.6 Dynamic channel selection
2.7 CSAT
2.8 Opportunistic SDL
2.9 Listen before Talk (LBT)
2.10 Channel access priority classes
2.11 Hidden node discovery
2.12 Discovery Reference Signals

What You Can Expect
■ Expert-Led Live Duration: 4 HOUR
■ Prerequisite: LTE Overview (eLearning)
## Technology Primer: Overview of CBRS

Exponentially rising data traffic, scarcity of spectrum, and expectations of enhanced user experience including 1Gbps data rates are driving operators to explore the use of shared spectrums such as CBRS – Citizens Broadband Radio Service. Operators can deploy LTE networks in 3.5 GHz CBRS spectrum using LAA. CBRS can be used in various business models including traditional mobile operators and new operators. CBRS also supports Private LTE networks. The course provides a high-level overview of the CBRS system, motivation for CBRS deployment, network architecture, network operation and deployment use cases.

### Intended Audience
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations.

### Objectives
After completing this course, the student will be able to:
- Define CBRS
- Differentiate Tiered licensing structure: IA, PAL and GAA
- Give examples of use cases for CBRS
- Sketch the architecture of a CBRS-based network
- Describe the roles of a CBSD, SAS, and ESC
- Step through key operations of CBRS

### What You Can Expect
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: LTE Overview (eLearning)

### Outline

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**Putting It All Together**
RF Design Workshop: Part 1 - LTE

LTE offers significant improvements over previous mobile wireless systems in terms of data speeds and capacity, through the use of technologies such as OFDMA and multiple antenna techniques. However, these gains are realized only with careful planning and design in the LTE Radio Access Network (RAN), to maximize the efficiency of available RF spectrum. This hands-on workshop guides participants through the theory and practice of RF design for LTE RANs. Participants will apply their understanding of the LTE air interface physical structure and related concepts to calculate the link budgets to support the market coverage and performance requirements. Participants will use coverage prediction tool for exercises to apply their knowledge and skills to real-world scenarios.

Intended Audience

This workshop is intended for LTE RF design and system performance engineers.

Objectives

After completing this course, the student will be able to:

■ Apply a consistent process to radio network design
■ Assess LTE RAN RF performance with RSRP and RSRQ measurements
■ Map network requirements to corresponding system parameters
■ Construct uplink/downlink link budgets to meet specific performance requirements
■ Use coverage and capacity requirements to determine the optimal radio network design
■ Exploit multiple antenna techniques to optimize coverage and performance

What You Can Expect

■ Expert-Led Live Duration: 16 HOUR
■ Prerequisite: Overview of OFDM (eLearning)
■ Prerequisite: LTE Overview (eLearning)
■ Required Equipment: PC laptop with administrator privileges

Outline

1. LTE Air Interface
   1.1 E-UTRAN architecture
   1.2 LTE Physical layer structure
   1.3 Air interface resources
   1.4 UE measurements (RSRP/RSRQ)
   1.5 RSRP/RSRQ exercises

2. Overview of LTE Radio Network Design
   2.1 Radio network design goals
   2.2 Planning inputs and outputs
   2.3 LTE RAN planning process

3. Market and Engineering Requirements
   3.1 Coverage requirements
   3.2 Capacity requirements
   3.3 QoS requirements
   3.4 Engineering requirements

4. LTE Link Budget
   4.1 Cell edge throughput calculations
   4.2 Link budget for UL and DL
   4.3 Role of RRH and TMA
   4.4 UL/DL link budget exercises

5. Antennas in LTE Networks
   5.1 Multiple antenna techniques
   5.2 Downlink feedback (CQI/RI/PMI)
   5.3 Deployment considerations
   5.4 Coverage prediction exercises

6. RF Design and Site Selection
   6.1 RF design process and options
   6.2 Morphology definitions
   6.3 Propagation models
   6.4 RF design tool configuration
   6.5 Coverage prediction

7. RF Configuration Parameters
   7.1 Sync signal and PCI planning
   7.2 Reference signal planning
   7.3 RA preamble planning
   7.4 PCI and RACH planning exercises

8. Advanced Features of LTE
   8.1 Carrier aggregation
   8.2 HetNet and eICIC support
   8.3 SON features

View Curriculum
With the introduction of LTE features such as Voice over LTE (VoLTE), multi-frequency, small cell deployment, and LTE-Advanced features, the existing RF design process needs to be enhanced. This workshop offers a foundation for features such as VoLTE, carrier aggregation, Heterogeneous Networks (HetNets), and small cells. The course revisits the data traffic driven link budget to reflect the VoLTE performance requirements and the differences for small cells. The antennas being planned to accommodate multi-band deployments are discussed, as well as the various RF parameters related to cell selection/re-selection and handover for proper load distribution in cases of multi-carrier and small cell deployment. In summary, this workshop provides a detailed understanding of RF design enhancements for VoLTE, LTE-Advanced and small cell.

### Intended Audience
This workshop provides practical examples and intertwines the exercises at every stage of the RF design process and is intended for RF designers, RF systems engineers, network engineers, deployment and operations personnel.

### Objectives
After completing this course, the student will be able to:
- Enumerate design considerations of deploying LTE in various scenarios
- Identify the key features of LTE-Advanced and their impact on RF design
- Discuss the link budget and planning for VoLTE, multi-frequency, and small cell deployment
- Sketch various antenna configurations
- Calculate the air interface capacity needs for data and VoLTE traffic
- Explain structure of RF design parameters related to cell selection, re-selection, and handover

### What You Can Expect
- Expert-Led Live Duration: 16 HOUR
- Prerequisite:LTE Overview (eLearning)
- Prerequisite: RF Design Workshop: Part 1-LTE
- Required Equipment: PC laptop with administrator privileges

### Outline

1. **LTE Radio Network Design Review**
   1.1 Radio network design goals, inputs and outputs
   1.2 LTE radio network planning process
2. **Antenna Considerations**
   2.1 Multi-band antenna considerations
   2.2 4x4 MIMO considerations
   2.3 RRH deployment configurations
   2.4 Integrated antenna considerations
3. **LTE Capacity Planning**
   3.1 Data and VoLTE traffic modeling
   3.2 Air interface capacity planning
4. **Link Budget for Small Cells**
   4.1 Review LTE link budget for macro network
   4.2 Small cell considerations
   4.3 Impact of Tx power, frequency, of antennas
   4.4 Pathloss for UL and DL
   **Exercise:** Link budget walk-through
5. **Link Budget for VoLTE**
   5.1 Link budget differences for VoLTE and data
   5.2 SINR requirement for VoLTE
   5.3 Use of RBs for VoLTE
   5.4 Pathloss for UL and DL
   **Exercise:** Link budget walk-through
6. **RF Design Considerations**
   6.1 RF design guidelines
   6.2 RF design tool configuration
   6.3 Coverage prediction
   **Exercise:** Coverage and interference
7. **Small Cell Parameter Configuration**
   7.1 Cell selection/reselection parameters
   7.2 Handover parameters

View Curriculum
This workshop provides insights into the symptoms and possible causes of field performance issues in LTE radio networks using UE logs. RF measurements related to coverage and interference are discussed to analyze coverage holes and overlapping regions. Students analyze LTE signaling messages through UE logs and map them to success and failure events. Students perform root cause analysis and gain an in-depth understanding of these signaling events to network performance. LTE RF optimization areas such as RRC connection setup, bearer drops, coverage issues. This knowledge transfer is obtained through hands-on experience using UE based diagnostic tools and scanner tools.

### Intended Audience
This workshop is primarily intended for RF and systems performance engineers involved in LTE design, performance, and optimization.

### Objectives
After completing this course, the student will be able to:
- Define the LTE RF KPIs and map them to RAN counters
- Identify various LTE signaling events that map to success and failure operational counters
- Identify the RF measurements that are key to coverage and interference
- Analyze the measurements through post processing tools
- Analyze UE logs for root cause analysis of successful and failure events
- Map above events to operational counters and corresponding KPIs
- Accessibility and RRC connection and bearer setup
- Radio link failures and bearer drops

### What You Can Expect
- Expert-Led Live Duration: 12 HOUR
- Prerequisite: Exploring LTE (series of self-paced eLearning)
- Required Equipment: PC laptop

### Outline

1. **Workshop Overview**

2. **LTE RAN KPIs**
   - 2.1 LTE RAN KPIs
   - 2.2 LTE signaling to KPI mapping
   - 2.3 Summary
   - 2.4 Review exercises

3. **Coverage Analysis**
   - 3.1 Defining the right coverage
   - 3.2 RSRP, RSRQ, SINR plot analysis
   - 3.3 Scanner data analysis
   - 3.4 Coverage analysis using post processing tool
   - 3.5 Summary
   - 3.6 Review exercises

4. **Accessibility KPI Analysis**
   - 4.1 PRACH parameter analysis
   - 4.2 Default bearer setup analysis
   - 4.3 Radio bearer setup and RRC reconfiguration
   - 4.4 Call flow to generic counter mapping
   - 4.5 Summary
   - 4.6 Review exercises

5. **Connection Drop Analysis**
   - 5.1 Radio link failure
   - 5.2 UE context drops
   - 5.3 E-RAB drops
   - 5.4 Drop KPIs and troubleshooting
   - 5.5 Summary
   - 5.6 Review exercises

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**View Curriculum**

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**EXPERT-LED LIVE, LTE_421**
LTE RF Optimization: Part 2– Downlink and Uplink Throughput

This workshop provides insights into the symptoms and possible causes of field performance issues in LTE radio networks using UE logs. RF measurements related to coverage and interference are discussed to analyze coverage holes and overlapping regions. Students analyze LTE signaling messages through UE logs and map them to success and failure events. Students perform root cause analysis and gain an in-depth understanding of these signaling events to network performance. LTE RF optimization areas such as downlink and uplink throughput analysis are addressed. This knowledge transfer is obtained through hands-on experience using UE based diagnostic tools and scanner tools.

Intended Audience
This workshop is primarily intended for RF and systems performance engineers involved in LTE design, performance, and optimization.

Objectives
After completing this course, the student will be able to:
- Define the LTE RF KPIs and map them to RAN counters
- Identify various LTE signaling events that map to success and failure operational counters
- Identify the RF measurements that are key to coverage and interference
- Analyze the RF measurements through post processing tools
- Analyze UE logs for root cause analysis of successful and failure events
- Map above events to operational counters and corresponding KPIs
- Understand LTE KPIs where they are pegged
- Describe DL and UL bandwidth and UE throughput

What You Can Expect
- Expert-Led Live Duration: 12 HOUR
- Prerequisite: Exploring LTE (series of self-paced eLearning)
- Prerequisite: LTE RF Optimization: Part 1 – Coverage and Accessibility (Instructor Led)
- Required Equipment: PC laptop

Outline
1. Workshop Overview
2. LTE RAN KPIs
   2.1 LTE RAN KPIs
   2.2 LTE signaling to KPI mapping
   2.3 Summary
   2.4 Review exercise
3. DL Data Traffic Performance
   3.1 DL traffic operation walk-through
   3.2 DL traffic KPIs
   3.3 Analysis of CQI, PMI, RI
   3.4 HARQ/ARQ and BLER analysis
   3.5 Summary
   3.6 Review exercises
4. UL Data Traffic Performance
   4.1 UL traffic operation walk-through
   4.2 UL traffic KPIs
   4.3 UL power control parameters
   4.4 HARQ/ARQ and BLER analysis
   4.5 Summary
   4.6 Review exercises

View Curriculum
LTE RF Optimization: Part 3 – Mobility and Inter-RAT

This workshop provides insights into the symptoms and possible causes of field performance issues in LTE radio networks using UE logs. RF measurements related to coverage and interference are discussed to analyze coverage holes and overlapping regions. Students analyze LTE signaling messages through UE logs and map them to success and failure events. Students perform root cause analysis and gain an in-depth understanding of these signaling events to network performance. LTE RF optimization areas such as Intra-LTE and IRAT handover operation. This knowledge transfer is obtained through hands-on experience using UE based diagnostic tools and scanner tools.

Intended Audience

This workshop is primarily intended for RF and systems performance engineers involved in LTE design, performance, and optimization.

Objectives

After completing this course, the student will be able to:

- Define the LTE RF KPIs and map them to RAN counters
- Identify various LTE signaling events that map to success and failure operational counters
- Analyze UE logs for root cause analysis of successful and failure events
- Map above events to operational counters and corresponding KPIs
- Intra LTE handovers and
- Inter-RAT handovers

What You Can Expect

- Expert-Led Live Duration: 12 HOUR
- Prerequisite: Exploring LTE (series of self-paced eLearning)
- Prerequisite: LTE RF Optimization: Part 1 – Coverage and Accessibility (Instructor Led)
- Required Equipment: PC laptop

Outline

1. Workshop Overview
2. Intra-LTE Handover Analysis
   2.1 Intra and Inter-frequency handover events and trigger parameters
   2.2 Handover KPIs/counters
   2.3 Handover execution: success and failure scenario
   2.4 Summary
   2.5 Review exercises
3. Inter-RAT Handover
   3.1 Idle mode system reselection
   3.2 Inter-RAT handover events and related trigger parameters
4. Idle Mode Performance
   4.1 Bearer inactivity timer
   4.2 Paging procedure optimization
   4.3 TAU procedure optimization
   4.4 Summary
   4.5 Review exercises
3.3 Inter-RAT handover message flow and related KPIs/generic counters
3.4 Handover execution: success and failure scenario
3.5 Summary
3.6 Review exercises
This workshop (part 4 of 4 parts series) provides insights into the symptoms and possible causes of field performance issues in LTE radio networks using UE logs. RF measurements related to coverage and interference are discussed to analyze coverage holes and overlapping regions. Students analyze LTE signaling messages through UE logs and map them to success and failure events. Students perform root cause analysis and gain an in-depth understanding of these signaling events to network performance. LTE RF optimization areas such as Intra-LTE and IRAT handover operation. This knowledge transfer is obtained through hands-on experience using UE based diagnostic tools and scanner tools.

### Intended Audience

This workshop is primarily intended for RF and systems performance engineers involved in LTE design, performance, and optimization.

### Objectives

After completing this course, the student will be able to:

- Identify the network and UE capabilities to support Carrier Aggregation
- Step through the successful operation of Carrier Aggregation using UE logs
- Identify various LTE signaling events that map to success and failure operational counters
- Identify the opportunities of load balancing in the idle and connected mode
- Analyze UE logs for root cause analysis of successful and failure events
- Map above events to operational counters and corresponding KPIs

### What You Can Expect

- Expert-Led Live Duration: 12 HOUR
- Prerequisite: Exploring LTE (series of self-paced eLearning)
- Prerequisite: LTE RF Optimization: Part 1 – Coverage and Accessibility (Instructor Led)
- Required Equipment: PC laptop

### Outline

1. **Workshop Overview**
2. **DL Carrier Aggregation Essentials**
   - 2.1 CA operation overview
   - 2.2 UE category and CA support capability
   - **Exercise:** Analysis of ‘UE Capabilities Response’ message
3. **Carrier Aggregation Operations**
   - 3.1 PCell setup signaling
   - 3.2 SCell configuration & typical criteria
   - 3.3 SCell configuration signaling
   - **Exercise:** Signaling log showing PCell setup & SCell configuration
   - 3.4 SCell activation & typical triggers
   - 3.5 DL CA traffic operations
   - 3.6 SCell de-activation & typical triggers
   - 3.7 SCell de-configuration & typical criteria
   - 3.8 Typical KPIs for DL CA
4. **Inter-Frequency Idle Mode Load Balancing**
   - 4.1 Inter-frequency cell re-selection operations
   - **Exercise:** SIB 3, 4, 5 parameter analysis
   - 4.2 Strategies for inter-frequency idle mode load balancing
   - 4.3 High priority to largest bandwidth
   - 4.4 Sticky carrier
   - 4.5 Dedicated Priorities
5. **Inter-Frequency Connected Mode Load Balancing (IFLB)**
   - 5.1 Event A4/A5 for IFLB handovers
   - 5.2 Measurement gaps and UE capability
   - 5.3 IFLB behavior with VoLTE
   - 5.4 Typical KPIs for IFLB

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This workshop (part 4 of 4 parts series) provides insights into the symptoms and possible causes of field performance issues in LTE radio networks using UE logs. RF measurements related to coverage and interference are discussed to analyze coverage holes and overlapping regions. Students analyze LTE signaling messages through UE logs and map them to success and failure events. Students perform root cause analysis and gain an in-depth understanding of these signaling events to network performance. LTE RF optimization areas such as Intra-LTE and IRAT handover operation. This knowledge transfer is obtained through hands-on experience using UE based diagnostic tools and scanner tools.

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**View Curriculum**
VoLTE Troubleshooting Workshop

This workshop focuses on End-to-End VoLTE troubleshooting techniques by examining specific failure examples throughout the VoLTE network encompassing IMS, EPC, and EUTRAN. The workshop provides practical experience in detecting, analyzing and resolving problems. The workshop emphasizes student participation via hands-on exercises allowing students to practice what they have learned. This workshop requires message traces of success and failure scenarios from the customer.

Intended Audience
This workshop is primarily intended for network performance and optimization engineers involved in monitoring and optimizing VoLTE operations in LTE networks.

Objectives
After completing this course, the student will be able to:

- Sketch a troubleshooting plan to tackle specific VoLTE failures,
- Demonstrate proficiency in VoLTE troubleshooting tasks
- Analyze VoLTE-related KPIs and identify issues in the network
- Use network traces and other resources to perform root-cause analysis of specific failures
- Analyze KPIs for VoLTE interworking scenarios and handovers
- Explain the QoS implementation for the VoLTE traffic plane
- Explain and analyze RTP and related traffic plane logs
- Analyze KPIs for VoLTE Lost Call Scenarios

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Exploring VoLTE: Architecture and Interfaces (self-paced eLearning)
- Prerequisite: Exploring VoLTE: Signaling and Operations (self-paced eLearning)
- Required Equipment: Laptop with access to tools used in the course

Outline

1. VoLTE Troubleshooting Overview
   1.1 VoLTE environment
   1.2 Failure categories
   1.3 Root causes of failures
   1.4 Failure analysis
   Exercise: Knowledge of tools/probes/protocol

2. VoLTE Call Setup Troubleshooting
   2.1 Categorize call setup outcomes
   2.2 Understanding prioritized cause codes
   2.3 Review call setup statistics
   2.4 VoLTE call failure signatures
   2.5 Analyze the Top Ten failures
   Exercise: Top Ten and EPS specific issues

3. VoLTE Drop Call Troubleshooting
   3.1 Categorize call drops
   3.2 Review VoLTE drop statistics
   3.3 VoLTE drop signatures
   Exercise: Call drop cause code chain

4. RTP-RTCP Timeout Drops
   4.1 What is an RTP timeout?
   Exercise: RTP timeout failure cases

5. Call Drops due to Mobility
   5.1 Non-3GPP handover attempts
   5.2 Intra-LTE handover failures
   Exercise: VoLTE mobility failure cases

6. VoLTE Traffic Quality
   6.1 Measuring quality: MOS, ACQ KPIs
   6.2 RTCP Reports from UEs
   6.3 Impact of high latency, jitter and packet loss
   6.4 Components of the latency budget
   Exercise: Quality KPIs
   6.5 Understanding audio gaps
   6.6 Review gap count and duration statistics
   6.7 Analyze gaps in a specific call
   Exercise: RTP flow information

7. Putting it all Together

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Exploring VoLTE: Architecture and Interfaces (self-paced eLearning)
- Prerequisite: Exploring VoLTE: Signaling and Operations (self-paced eLearning)
- Required Equipment: Laptop with access to tools used in the course

Objective
After completing this course, the student will be able to:

- Sketch a troubleshooting plan to tackle specific VoLTE failures,
- Demonstrate proficiency in VoLTE troubleshooting tasks
- Analyze VoLTE-related KPIs and identify issues in the network
- Use network traces and other resources to perform root-cause analysis of specific failures
- Analyze KPIs for VoLTE interworking scenarios and handovers
- Explain the QoS implementation for the VoLTE traffic plane
- Explain and analyze RTP and related traffic plane logs
- Analyze KPIs for VoLTE Lost Call Scenarios

View Curriculum
VoLTE RAN Performance Workshop

This workshop focuses on radio aspects of VoLTE performance by examining specific examples such as VoLTE setup analysis, Drop call analysis, voice quality analysis, and voice capacity analysis. The workshop provides practical experience in detecting, analyzing and resolving problems. The workshop emphasizes student participation via hands-on exercises allowing students to practice what they have learned. This workshop requires UE and network traces of success and failure scenarios from the customer.

Intended Audience

This workshop is primarily intended for RAN performance and optimization engineers involved in monitoring and optimizing VoLTE operations in LTE networks.

Objectives

After completing this course, the student will be able to:

- Sketch a troubleshooting plan to tackle specific VoLTE failures
- Demonstrate proficiency in VoLTE troubleshooting tasks
- Analyze VoLTE-related KPIs and identify issues in the network
- Use UE and network traces to perform root-cause analysis of specific failures
- Analyze VoLTE Setup, Drops, and voice quality performance issues
- Explain and analyze RTP and related traffic plane logs

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Exploring VoLTE: Architecture and Interfaces (self-paced eLearning)
- Prerequisite: Exploring VoLTE: Signaling and Operations (self-paced eLearning)
- Required Equipment: Laptop with access to tools used in the course

Outline

1. VoLTE Troubleshooting Overview
   1.1 Components of VoLTE calls
   1.2 Failure categories
   1.3 RAN KPIs for VoLTE
   Exercise: Knowledge of tools/probes/protocol

2. VoLTE Call Setup Analysis
   2.1 Accessibility KPIs
   2.2 Default and Dedicated bearer setup for VoLTE
   2.3 VoLTE call setup failure signatures
   2.4 Review call setup statistics
   Exercise: Case Study: VoLTE Call Setup failure

3. VoLTE Call Drop Analysis
   3.1 VoLTE Call Drop KPIs
   3.2 Use of TTI Bundling
   3.3 VoLTE call drop failure signatures
   3.4 Review call drop statistics
   Exercise: Case Study: VoLTE Drops

4. VoLTE Call Quality Analysis
   4.1 Measuring quality: MOS, ACQ KPIs
   4.2 RTCP Reports from UEs
   4.3 Impact of high latency, jitter and packet loss
   4.4 Components of the latency budget
   4.5 Understanding audio gaps
   4.6 Review gap count and duration statistics
   4.7 Analyze gaps in a specific call
   Exercise: Case Study: RTP Flow and Audio Gaps

5. VoLTE Capacity Analysis
   5.1 VoLTE Capacity KPIs
   5.2 PDCCH capacity and Semi-persistent Scheduling
   Exercise: Case Study: Connected User and PDCCH Analysis

View Curriculum
Introduction to VoLTE

Since its standardization over a decade ago, VoLTE, or Voice over LTE, has been deployed by operators around the world. Compared to the traditional circuit-based 2G/3G voice solutions, VoLTE provides better voice experiences, enables rich multi-media communications features, and makes the network more efficient for operators. This course provides an overview of the LTE and IMS network architecture supporting VoLTE, and the key technologies used in VoLTE such as IMS and SIP. The course also covers high level information on key scenarios in VoLTE signaling and operations, media support, VoLTE interworking, roaming, and air interface enhancements for VoLTE. This course is delivered in a blended format, including two live web sessions along with self-paced multimedia content, allowing students to learn in bite-sized chunks over a three-week interval.

Intended Audience

This blended (self-paced and instructor-led) course is intended for a technical audience looking for an overview of the drivers for VoLTE and a basic understanding of the underlying technologies being considered.

Objectives

After completing this course, the student will be able to:

- Describe the architectural elements of the LTE and IMS networks used to support VoLTE
- Discuss benefits of VoLTE compared to traditional circuit-based 2G/3G voice
- Explain key VoLTE signaling and operational scenarios including registration and call processing
- Identify the key technology building blocks needed for VoLTE
- Describe the network functions involved in VoLTE interworking and roaming
- Discuss key air interface enhancements for VoLTE
- List the key KPIs (Key Performance Indicators) used to measure VoLTE performance

What You Can Expect

- Self-Paced Duration: 6 HOUR
- Expert-Led Live Duration: 2 HOUR
- Total Program Duration: 4 WEEK
- Prerequisite: Welcome to LTE (eLearning)

Outline

1. Kickoff Session [Live: Web-based]
   1.1 Course Overview
   1.2 VoLTE Overview

2. The LTE Network
   2.1 LTE RAN and Core
   2.2 LTE Attach and PDN Connection Setup
   2.3 QoS in LTE
   2.4 IMS Architecture

3. VoLTE Operations
   3.1 VoLTE Registration
   3.2 VoLTE Call Origination/Termination
   3.3 EPS Bearers and DRBs for VoLTE

4. VoLTE Media
   4.1 Media Path and RTP
   4.2 Introduction to 5G New Radio
   4.3 Audio Codecs for VoLTE
   4.4 RoHC and Other Air Interface Enhancements

5. VoLTE Interworking
   5.1 VoLTE to 3G/PSTN Call Setup
   5.2 3G/PSTN to VoLTE Call Setup
   5.3 Outbound Roaming

6. KPIs
   6.1 KPIs and Failures Overview

7. Review Session [Live: Web-based]
IP and Ethernet
IP and Ethernet

We help our customers tackle technology, faster.

Curriculums include:

- **SELF-PACED**
  - Ethernet Basics
  - Ethernet VLANs
  - Ethernet Bridging
  - IP Basics
  - Interconnecting in IP Networks
  - IP Quality of Service (QoS)
  - IP Routing
  - TCP and Transport Layer Protocols
  - Welcome to IPv6
  - Wireshark Overview
Ethernet Basics

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP networks, a solid understanding of Ethernet and its role in networking is essential. Ethernet is native to IP and has been adopted in various forms by the communication industry. A solid foundation in IP and Ethernet has become a basic job requirement in the industry. Starting with a brief history, the course provides a focused basic level introduction to the fundamentals of Ethernet technology. It is a modular introductory course only on Ethernet basics as part of the overall eLearning IP fundamentals curriculum.

Intended Audience
This course is intended for those seeking a basic level introduction to Ethernet technology.

Objectives
After completing this course, the student will be able to:
- Define Ethernet
- Summarize the key variations of the Ethernet family of standards
- Discuss Ethernet addressing and frame structure
- Discuss Ethernet services offered by carriers

What You Can Expect
- Self-Paced Duration: 1.5 HOUR

Outline

1. Ethernet Defined
   1.1 What is Ethernet?
   1.2 CSMA/CD

2. Ethernet Standards
   2.1 Media and Connectors
   2.2 Auto Negotiation

3. Ethernet Addressing and Frame Structure
   3.1 Details of MAC addresses
   3.2 Ethernet frame structure

4. Carrier Ethernet
   4.1 Definition and Service types
   4.2 SLA and Service Continuity

Putting It All Together
Ethernet VLANs

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP networks, a solid understanding of Ethernet and its role in networking is essential. Ethernet is native to IP and has been adopted in various forms by the telecom industry as the Layer 1 and Layer 2 of choice. VLANs are used extensively in the end-to-end IP network and a solid foundation in IP and Ethernet has become a basic job requirement for the carrier world. Starting with a brief history, the course provides a focused basic level introduction to the fundamentals of Ethernet VLAN technology. It is a modular introductory course only on Ethernet VLAN basics as part of the overall eLearning IP fundamentals curriculum. The course includes a pre-test and a post-test.

Intended Audience
This course is intended for those seeking a basic level introduction to Ethernet Bridging.

Objectives
After completing this course, the student will be able to:
- Define Ethernet VLANs
- Identify Ethernet VLAN applications and benefits
- Summarize the key variations of the Ethernet family of standards to support VLANs
- Identify the key types of Ethernet VLANs
- Describe VLAN Trunks and their purpose

What You Can Expect
- Self-Paced Duration: 1.5 HOUR

Outline
1. Virtual Local Area Networks (VLANs)
   1.1 VLAN Definition
   1.2 Characteristics of LAN
   1.3 Packet flow in VLAN
   1.4 Advantages of VLAN
2. VLAN Application and Benefits
   2.1 VLAN Applications
   2.2 VLAN Benefits
3. Single Switch VLANs
   3.1 Port based VLAN
4. Multi-Switch VLANs: Trunks and Tagging
   4.1 Multi-Switch VLANs
   4.2 VLAN tags
   4.3 VLAN Trunks
Putting It All Together
Ethernet Bridging

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP networks, a solid understanding of Ethernet and its role in networking is essential. Ethernet is native to IP and has been adopted in various forms by the telecom industry as the Layer 1 and Layer 2 technology of choice. Ethernet bridging and associated capabilities are used extensively in the end-to-end IP network and a solid foundation in IP and Ethernet has become a basic job requirement in the carrier world. Starting with a brief history, the course provides a focused basic level introduction to the fundamentals of Ethernet Bridging as a key capability of Ethernet based nodes. It is a modular introductory course only on Ethernet Bridging basics as part of the overall eLearning IP fundamentals curriculum.

Intended Audience

This course is intended for those seeking a basic level introduction to Ethernet Bridging.

Objectives

After completing this course, the student will be able to:
- Introduce Ethernet bridges and explain how they operate
- Introduce Ethernet switches and explain how they differ from Ethernet bridges
- Discuss Spanning Tree Protocol and its variations
- Introduce the concept of multilayer switching
- Discuss the use of link aggregation group in Ethernet networks

What You Can Expect

- Self-Paced Duration: 1.5 HOUR

Outline

1. Ethernet Bridge
   1.1 Definition
   1.2 History
   1.3 Learning bridge

2. Ethernet Switch
   2.1 Definition
   2.2 History
   2.3 Ethernet switching
   2.4 Full duplex operation

3. Spanning Tree Protocol (STP)
   3.1 Function
   3.2 Operation
   3.3 Variants

4. Multilayer Switch (MLS)
   4.1 Definition
   4.2 Function

5. Link Aggregation Group
   5.1 Definition
   5.2 Uses

6. Summary
**IP Basics**

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP, a solid understanding of IP and its role in networking is essential. IP is to data transfer as what a dial tone is to a wireline telephone. A fundamental knowledge of IPv4 and IPv6 networking along with use of VLANs is a must for all telecom professionals. A solid foundation in IP has become a basic job requirement in the carrier world. Starting with a brief history, the course provides a focused basic level introduction to the fundamentals of IP technology. It is a modular introductory course only on IP basics as part of the overall eLearning IP fundamentals curriculum.

**Intended Audience**

This course is intended for those seeking a basic level introduction to the Internet Protocol (IP).

**Objectives**

After completing this course, the student will be able to:

- Describe the purpose and structure of an IP address
- Describe network prefix
- Explain the purpose of CIDR Prefix
- Explain the purpose of Subnet Mask
- Describe IP Subnets
- Explain the IP header and its key fields
- Describe broadcasting in IP networks
- Describe multicasting in IP networks

**What You Can Expect**

- Self-Paced Duration: 1 HOUR

**Outline**

1. **IP Address**
   - 1.1 IP address Structure
   - 1.2 CIDR based IP address
   - 1.3 IP address examples

2. **IP Subnets**
   - 2.1 IP subnet definition
   - 2.2 Subnet creation principle
   - 2.3 Subnet creation Example

3. **IP Header**
   - 3.1 IP Header fields description
   - 3.2 Importance of TTL field in IP header

4. **Multicast and Broadcast**
   - 4.1 Broadcast Operations
   - 4.2 Multicast Operations

**Putting It All Together**
Interconnecting in IP Networks

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP networks, a solid understanding of IPv4 and IPv6 networking along with their use for inter-networking is a must for all telecom professionals. As the services and applications of wireless networks continue to expand, the backbone must evolve to support them. Multi-Protocol Label Switching (MPLS) is designed to make the backbone fast, scalable and manageable, and capable of carrying heavy traffic, supporting QoS. This course presents a technical overview including a discussion on the architecture of MPLS, the components of the MPLS network and the supporting protocols required for MPLS. It is a modular introductory course only on MPLS basics as part of the overall eLearning IP fundamentals curriculum.

Intended Audience
This course is intended for anyone seeking a basic level overview of the MPLS and IP interconnecting architectures.

Objectives
After completing this course, the student will be able to:
- Describe the motivation behind MPLS
- State the role of MPLS in the convergence of networks
- List key applications of MPLS
- Sketch the architecture of MPLS
- Describe the important components and operations of MPLS
- Describe how MPLS is used to set up layer 3 and layer 2 VPNs

What You Can Expect
- Self-Paced Duration: 1.5 HOUR

Outline
1. Why MPLS?
   1.1 Advantages of MPLS
   1.2 New applications
2. MPLS Networks
   2.1 MPLS domain
   2.2 Label edge router
   2.3 Label switch router
3. MPLS Terminology
   3.1 Label Switched Paths (LSP)
   3.2 Forward Equivalence Class (FEC)
   3.3 Structure of a label
4. Packet Forwarding Along LSPs
   4.1 Label Forwarding Information Base (LFIB)
   4.2 Packet forwarding along LSPs
   4.3 Label stacking
5. MPLS and Virtual Private Networks
   5.1 VPNs support in MPLS
   5.2 Layer 3 and Layer 2 VPNs establishment in MPLS
   5.3 Label stacking and VPNs
   5.4 MPLS based L2 VPN solutions
IP Quality of Service (QoS)

The Internet is coming to a new age where various applications have their own QoS requirements, and one size definitely does not fit all. This course introduces the concept of QoS and discusses the current limitations within the Internet. The new services requirements driving QoS in the Internet are presented. The two basic techniques used for QoS - Integrated Services and Differentiated Services - are presented. The discussion includes the benefits and limitations of the Integrated Services and the Differentiated Services approaches to QoS. While IntServ and DiffServ are the approaches, service providers need an infrastructure to deploy QoS-based applications rapidly. This course describes the policy-based QoS architecture which supports the infrastructure for delivering QoS based applications. Finally, emerging trends in IP QoS are introduced.

Intended Audience

This course is intended for anyone seeking an overview of the IP Quality of Service architectures in the Internet.

Objectives

After completing this course, the student will be able to:

- Determine the limitations of the best effort approach to QoS
- Describe the need for QoS with respect to new applications
- Explain how QoS requirements are communicated
- Define policy-based architecture
- Explain the benefits and limitations of the Integrated Services approach to QoS
- Explain the benefits and limitations of the Differentiated Services approach to QoS
- Describe the protocols that are used for each of the QoS approaches
- Identify emerging trends in IP QoS

What You Can Expect

- Self-Paced Duration: 3 HOUR

Outline

1. Motivation for Quality of Service (QoS)
   - 1.1 Definition of Quality of Service
   - 1.2 Service examples
   - 1.3 QoS parameters

2. QoS in today's Internet
   - 2.1 Current QoS mechanisms
   - 2.2 Limitations of the current QoS mechanisms

3. QoS Requirements
   - 3.1 Requirements of QoS on the Internet
   - 3.2 Service Level Agreements (SLAs)
   - 3.3 Challenges for deploying IP QoS
   - 3.4 Policy based QoS architecture

4. QoS Models
   - 4.1 Application approach vs. aggregated approach
   - 4.2 Introduction to IP QoS models

5. Integrated Services Approach (IntServ)
   - 5.1 Limitations of the Integrated Services approach
   - 5.2 ReSerVation Protocol (RSVP)

6. Differentiated Services Approach (DiffServ)
   - 6.1 Differentiated services approach
   - 6.2 DiffServ protocol
   - 6.3 DiffServ implementation
   - 6.4 Traffic management functions
   - 6.5 Issues with DiffServ

7. Emerging Trends in QoS
   - 7.1 Hybrid architectures
   - 7.2 Automated QoS management
   - 7.3 Bandwidth brokers

8. Summary
   - 8.1 Put It All Together
   - 8.2 Assess the knowledge of the participant based on the objectives of the course
**IP Routing**

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP, an understanding of IP and its role in networking is essential. IP is to data transfer as a dial tone is to a wireline telephone. A fundamental knowledge of IPv4 and IPv6 networking along with use of routing is a must for all telecom professionals. A solid foundation in IP and routing has become a basic job requirement in the carrier world. Understanding of IP routing protocols is an important part of building this foundation. Starting with a basic definition, the course provides a focused base level introduction to the fundamentals of IP routing and associated protocols like OSPF, BGP, and VRRP. It is a modular introductory course only on IP routing as part of the overall eLearning IP fundamentals curriculum.

**Intended Audience**
This course is intended for those seeking a basic level introduction to IP routing and the common associated protocols.

**Objectives**
After completing this course, the student will be able to:
- Define the differences between IP routing and forwarding
- Distinguish between Interior Gateway Protocols and Exterior Gateway Protocols
- Explain Open Shortest Path First (OSPF) and how it is used
- List the main types of Link State Advertisements in OSPF
- Describe Border Gateway Protocol (BGP) and how it is used
- Show how route reflectors simplify network configuration and reduce routing overhead
- Explain how PING can be used to verify end-to-end connectivity in an IP Network
- Describe how Traceroute can be used to track down routing errors in a network

**What You Can Expect**
- Self-Paced Duration: 2 HOUR

**Outline**

1. **What is IP routing?**
   - 1.1 IP routing basics
   - 1.2 Routing and forwarding
   - 1.3 Routing protocols

2. **Open Shortest Path First (OSPF)**
   - 2.1 OSPF basics
   - 2.2 A closer look at OSPF

3. **Border Gateway Protocol (BGP)**
   - 3.1 BGP basics
   - 3.2 A closer look at BGP
   - 3.3 Scaling BGP

4. **Redundancy Protocols**
   - 4.1 Introduction
   - 4.2 VRRP
   - 4.3 GLBP

5. **Debugging Tools and Utilities**
   - 5.1 PING
   - 5.2 Traceroute

6. **Summary**
TCP and Transport Layer Protocols

As the communications industry transitions to wireless and wireline converged networks to support voice, video, data and mobile services over IP, a solid understanding of IP and its role in networking is essential. IP is to data transfer as what a dial tone is to a wireline telephone. A fundamental knowledge of IPv4 and IPv6 networking along with use of IP based transport protocols is a must for all telecom professionals. Understanding of TCP and other IP based transport layer protocols is an important part of building this foundation. Starting with a basic definition, the course provides a focused basic level introduction to the fundamentals of IP based transport layer protocols like TCP, UDP and SCTP. It is a modular introductory course only on IP basics as part of the overall eLearning IP fundamentals curriculum.

Intended Audience

This course is intended for those seeking a basic level introduction to the IP-based transport layer protocols - TCP, UDP and SCTP.

Objectives

After completing this course, the student will be able to:
- Explain the key transport layer functions and the concept of ports
- Describe User Datagram Protocol (UDP) and Transmission Control Protocol (TCP)
- Explain how TCP provides reliable communication over IP and achieves optimal transmission
- Define the special requirements for carrying telecom signaling over IP networks
- List the key functions of Stream Control Transmission Protocol (SCTP)

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. Overview of the Transport Layer
   1.1 Functions of the Transport Layer
2. User Datagram Protocol (UDP)
   2.1 Defining the UDP
   2.2 UDP header details
3. Transmission Control Protocol (TCP)
   3.1 TCP functionality
   3.2 TCP connection setup
4. Stream Control Transport Protocol (SCTP)
   4.1 Role of SCTP
   4.2 Capabilities of SCTP
   4.3 Unique features of SCTP
5. Summary
   Putting It All together

View Curriculum
Welcome to IPv6

As the communications industry transitions to wireless, wireline converged networks to support voice, video, data and mobile services over IP networks, a solid understanding of IP and its role in networking is essential. IP is to data transfer as a dial tone is to a wireline telephone. IPv6 was defined in 1998 but saw little adoption for over a decade. With continued IPv4 address depletion and the migration to wireless VoIP in LTE networks, the time for widespread adoption has finally arrived. This course begins with a look at the motivation for migrating to IPv6, followed by an explanation of the IPv6 header and addressing concepts, and the 128-bit address necessitates changes to many of the supporting protocols for IP. The course concludes with a look at the various approaches to migrating from IPv4 to IPv6 and how these are deployed in LTE networks.

Intended Audience

This course is intended for technical personnel with a grounding in IPv4 networks who are seeking a technical overview of IPv6 and related protocols.

Objectives

After completing this course, the student will be able to:

- Describe why the migration to IPv6 is finally happening
- List the key benefits of IPv6
- Explain key fields in the IPv6 header
- Discuss how IPv6 addresses are formatted and how they are assigned
- Explain how the basic IP supporting protocols are enhanced to support IPv6
- Describe how automatic routing for IPv6 networks is enabled by BGP and OSPF
- Discuss how dual stack devices help ease the transition from IPv4 to IPv6
- Understand the differences between configured and automatic tunnels for IPv6 transition

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. Motivation and Benefits
   1.1 IPv4 address depletion
   1.2 Limitations of NAT
   1.3 Benefits of IPv6

2. IPv6 Header and Addresses
   2.1 Header format
   2.2 Address format
   2.3 Address notation
   2.4 Types of addresses
   2.5 Address assignment

3. Supporting Protocols
   3.1 ICMP
   3.2 DNS
   3.3 DHCP
   3.4 OSPF
   3.5 BGP

4. Transition to IPv6
   4.1 The transition problem
   4.2 Dual stack
   4.3 Configured tunneling
   4.4 Automatic tunneling
   4.5 IPv6 in LTE
Wireshark Overview

Wireshark is an open-source protocol capture and analysis tool used by many wireless operators to help evaluate network performance and debug end-to-end operational failures. This self-paced eLearning course provides a high-level look at Wireshark and its key capabilities, taking a step-by-step approach to show the main elements of the user interface, the process of capturing and analyzing traces, and a brief overview of how Wireshark can be used to evaluate typical signaling flows in VoLTE networks. Frequent interactions are used to ensure student comprehension and engagement at every stage.

Intended Audience

This course is suitable for those looking for a high level introduction to Wireshark and how it may be used to evaluate and debug field issues.

Objectives

After completing this course, the student will be able to:

■ Set up the elements of the user interface and Wireshark to their personal tastes
■ Capture a network trace from their PC and save the packet capture file
■ Search and select protocols and packets.
■ Modify the time display and reference
■ Analyze elements of IMS/VoIP protocols (i.e. SIP) and display a VoIP call graph

What You Can Expect

■ Self-Paced Duration: 1 HOUR

Outline

1. User Interface
   1.1 UI elements
   1.2 Menu items

2. Capturing and Displaying Data
   2.1 Capturing and saving traces
   2.2 File management
   2.3 Capture Filters

3. Wireshark Features
   3.1 Filters and searching
   3.2 Time display, reference, and shift
   3.3 Using host files

4. Analyzing SIP Messages
   4.1 SIP messages
   4.2 VoIP call Flow
   4.3 SIP filters
Network Virtualization
Network Virtualization

2020 Course Roadmap

SELF-PACED
Welcome to SDN and NFV Introductions
Welcome to SDN and NFV Foundations
Welcome to SDN and NFV Technologies

TECH PRIMER
Containers and Microservices in Telecom
VxLAN and Segment Routing

Containerized Network Functions Architecture and Operations

OpenStack Workshop for SDN and NFV

Container Workshop using Docker

TOSCA and YANG Workshop

Container Orchestration Workshop
Network Virtualization

We help our customers tackle technology, faster.

Curriculums include:

- **5G and IoT**
- **Automation and Insights**
- **LTE and VoLTE**
- **IP and Ethernet**
- **Network Virtualization**

**SELF-PACED**
- API Overview
- Big Data Overview
- Cloud RAN Overview
- NFV Overview
- OpenStack IaaS Overview
- SDN Overview
- Virtualization and Cloud Overview
- Welcome to SDN and NFV Introductions
- Welcome to SDN and NFV Foundations
- Welcome to SDN and NFV Technologies

**EXPERT-LED LIVE**
- Containers and Microservices in Telecom
- VxLAN and Segment Routing
- SDN and NFV Architecture and Operations
- Containerized Network Functions Essentials
- Containerized Network Functions Architecture and Operations
- OpenStack Workshop for SDN and NFV
- Container Workshop using Docker
- Container Orchestration Workshop
- TOSCA and YANG Workshop
- NETCONF/YANG Configuration Workshop
- Accelerating Digital Transformation
- Network Virtualization Workshop for Leaders
API Overview

Wireless, wireline and cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and wireless, wireline and cable service provider business paradigms is essential for professionals in the communication industry. This course explores the technology behind Application Programming Interfaces (APIs), details the requirements and benefits of using APIs, and describes how to leverage APIs as part of network transformation.

Intended Audience

The course is intended for all that are interested in understanding what APIs are and how they will enable the transformation of the Wireless, Wireline and Cable service provider networks over the next few years.

Objectives

After completing this course, the student will be able to:

- Outline the concept of Application Programming Interfaces (APIs)
- Describe how to leverage APIs as part of the Network Transformation
- Identify three possible examples of APIs

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. What is an API?
   1.1 API defined
   1.2 What is an API?
2. Why APIs?
   2.1 Benefits of APIs
   2.2 Requirements of APIs
3. Using APIs
   3.1 API In action: End-to-end view of API
4. API Process
   4.1 Simplified API process

5. Technology Behind APIs
   5.1 RESTful APIs
   5.2 OAuth2

6. APIs and Network Transformation
   6.1 APIs and network transformation
   6.2 Example: OpenStack APIs for VM Instantiation
   6.3 Example: APIs in Software-Defined Networking

7. API Examples
   7.1 Data center example
   7.2 Wireless network example
   7.3 What is an API platform?

8. End of Course Assessment
Big Data Overview

Wireless, wireline and cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and wireless, wireline and cable service provider business paradigms is essential for professionals in the communication industry. This course looks at the drivers and technology behind Big Data, including Hadoop and MapReduce. It explores the basics of data visualization and details several big data examples.

Intended Audience

The course is intended for all that are interested in understanding what Big Data is and how it will transform the Wireless, Wireline and Cable service provider networks over the next few years.

Objectives

After completing this course, the student will be able to:

■ Describe the concept of Big Data
■ Illustrate the Big Data architecture and key protocols
■ Describe a possible use case for Big Data

What You Can Expect

■ Self-Paced Duration: 1 HOUR

Outline

1. What is Big Data?
   1.1 Traditional Business Intelligence
   1.2 Big Data Drivers
2. Big Data Technology
   2.1 Commercial and Open Source
3. Hadoop Procedure
   3.1 Why use Hadoop
   3.2 Sample Hadoop Suite
   3.3 How does Hadoop work?
4. Hadoop Modules
   4.1 Hadoop Distributed File System (HDFS)
   4.2 MapReduce
   4.3 Hadoop Plugins
5. Big Data Insights
   5.1 Insights form data sources
6. Data Visualization
   6.1 Data Visualization Basics
7. Data Visualization Examples
   7.1 Word cloud
   7.2 Tree Maps
   7.3 Heat Map
8. Big Data Examples
   8.1 Big Data in Social Media
   8.2 Big Data in Healthcare

Putting It All Together
Cloud RAN Overview

Wireless, wireline and cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and wireless, wireline and cable service provider business paradigms is essential for professionals in the communication industry. This course focuses on the architecture, key protocols and operational benefits of Cloud RAN, including the benefits and challenges of having a centralized, cloud-based architecture for radio access networks.

Intended Audience

The course is intended for all that are interested in understanding what Cloud RAN is and how it will transform the Wireless, Wireline and Cable service provider networks over the next few years.

Objectives

After completing this course, the student will be able to:
- Describe the concept of Cloud RAN
- Illustrate the Cloud RAN architecture and key protocols
- Describe the operational benefits of Cloud RAN

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. Current RAN Architecture
   1.1 RAN architecture
   1.2 Macro cells
   1.3 Small cells
   1.4 RAN connectivity

2. Challenges of Today
   2.1 RAN equipment requirements
   2.2 RAN power requirements

3. Why Cloud RAN?
   3.1 Problems Cloud RAN solves

4. Cloud RAN Architecture
   4.1 Remote radio head
   4.2 Baseband unit
   4.3 Fronthaul

5. Benefits and Challenges
   5.1 OpEx/CapEx
   5.2 Operational
   5.3 Radio
   5.4 Mobility

6. Baseband Unit Virtualization
   6.1 Virtualization of BBU overview
   6.2 Virtualized BBU-Pool
   6.3 Advantages of Virtualizing BBU

7. Connectivity Topologies
   7.1 Fronthaul technologies
   7.2 Fronthaul protocols

8. Cloud RAN and Virtualization
   8.1 C-RAN interworking with NFV
   8.2 C-RAN interworking with SDN

9. End of Course Assessment
NFV Overview

Wireless, wireline and cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and wireless, wireline and cable service provider business paradigms is essential for professionals in the communication industry. This course provides a high-level view of Network Functions Virtualization (NFV), including the motivations, challenges, and impact of NFV, the key components of the NFV architecture, and several NFV examples.

Intended Audience

The course is intended for all that are interested in understanding what NFV is and how it will transform the Wireless, Wireline and Cable service provider network over the next few years.

Objectives

After completing this course, the student will be able to:

■ Describe the concept of Network Functions Virtualization
■ List the motivations, challenges and impact of NFV
■ List the key components of the NFV architecture

What You Can Expect

■ Self-Paced Duration: 1 HOUR

Outline

1. NFV Overview
   1.1 Network Functions Virtualization (NFV)
   1.2 NFV defined
2. NFV Motivation and Benefits
   2.1 Motivation for NFV
   2.2 Potential NFV benefits
3. NFV Architectural Framework
   3.1 NFV framework
   3.2 High-level NFV framework
4. NFV Challenges
5. NFV and IMS
   5.1 Simplified IMS functions
   5.2 Virtualized IMS functions
6. NFV and LTE
7. NFV and Content Delivery Networks
8. NFV Examples
   8.1 Hardware failure
   8.2 NFV for elastic capacity
9. End of Course Assessment

View Curriculum
OpenStack IaaS Overview

Wireless, Wireline and Cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and Wireless, Wireline and Cable service provider business paradigms is essential for professionals in the communication industry. This course provides a high level view of the architecture and operations of OpenStack. The key services families of Keystone, Glance, Nova, Neutron, Cinder, Swift, Ceilometer, and Heat are explored including their architecture, services, and their communication with other services.

Intended Audience
The course is intended for all that are interested in understanding what OpenStack is and how it will transform the Wireless, Wireline and Cable service provider networks over the next few years.

Objectives
After completing this course, the student will be able to:
- Identify the main service families of OpenStack
- List the key resources that are virtualized with OpenStack
- Explain how OpenStack communicates internally with the RabbitMQ and externally with APIs

What You Can Expect
- Self-Paced Duration: 1 HOUR

Outline
1. OpenStack IaaS Architecture
   1.1 OpenStack IaaS
   1.2 OpenStack release timeline
2. OpenStack Communication
   2.1 OpenStack APIs
   2.2 RabbitMQ
3. OpenStack Basic Services
   3.1 Keystone and authentication
   3.2 Glance and image store
4. Compute Resources and Nova
   4.1 Nova architecture
   4.2 Nova scheduling
5. Network Resources and Neutron
   5.1 Neutron architecture
   5.2 Neutron services
6. Storage Resources, Cinder and Swift
   6.1 Types of storage
   6.2 Cinder vs. Swift
   6.3 Storage and Glance
7. Ceilometer and Monitoring
   7.1 Telemetry meter types
   7.2 Using Ceilometer
8. Orchestration and Heat
   8.1 What is Orchestration?
   8.2 Heat and Automation
   8.3 Heat templates

End of Course Assessment
SDN Overview

Wireless, wireline and cable service providers are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and wireless, wireline and cable service provider business paradigms is essential for professionals in the communication industry. This course provides a high-level view of Software Defined Networks, including the key components of the SDN architecture and possible use cases of SDN.

Intended Audience

The course is intended for all that are interested in understanding what SDN is and how it will transform the Wireless, Wireline and Cable service provider network over the next few years.

Objectives

After completing this course, the student will be able to:
- Describe the concept of Software Defined Networks (SDN)
- List the key components of the SDN architecture
- Identify possible uses of SDN

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. SDN Overview
   1.1 SDN: Centralized control, distributed traffic
   1.2 SDN defined

2. SDN Motivations and Benefits
   2.1 Motivation for SDN
   2.2 Potential SDN benefits

3. Routing and Forwarding
   3.1 Routing and forwarding
   3.2 Routing in action
   3.3 Forwarding in action
   3.4 Control plane and forwarding plane inside a router

4. SDN Principles
   4.1 The SDN way
   4.2 The Hybrid way

5. SDN Architecture
   5.1 SDN architecture
   5.2 SDN controller for flow rules
   5.3 SDN switch for forwarding

6. SDN in Action
   6.1 SDN flow rules in action
   6.2 SDN forwarding in action

7. Using SDN
   7.1 SDN: Hybrid approach
   7.2 SDN: Bandwidth on demand service

8. SDN Challenges

9. End of Course Assessment
Virtualization and Cloud Overview

Mobile Communication Service Providers (CSPs) are on the cusp of a multitude of network and business transformation choices. A good conceptual understanding of the new networking and CSP business paradigms is essential for professionals in the communication industry. This course provides a high level view of the impact and benefits of the cloud infrastructure, the benefits of virtualization, the vision and opportunities created by future CSP networks, as well as an overview of the impact of OpenStack cloud infrastructure on the service provider’s network.

Intended Audience

The course is intended for all that are interested in understanding what OpenStack is and how it will transform the CSP network over the next few years.

Objectives

After completing this course, the student will be able to:

- Identify the main elements of virtualization
- List the key components of cloud Infrastructure as a Service (IaaS)
- Describe the role of Orchestration

What You Can Expect

- Self-Paced Duration: 1 HOUR

Outline

1. Key Attributes of Cloud Computing
2. Virtualization
   - 2.1 Why Virtualization?
   - 2.2 A real world example – Virtualization
3. Virtual Machine and Hypervisor
   - 3.1 Virtual machine
   - 3.2 The Hypervisor
   - 3.3 Hypervisor defined
4. Functions of the Hypervisor
   - 4.1 Functions of the Hypervisor
   - 4.2 Networking in the virtual world
5. The Cloud
   - 5.1 Why Cloud?
   - 5.2 Multi-tenancy (users) in action
6. The Role of the Orchestrator
   - 6.1 Cloud orchestration
   - 6.2 Cloud Orchestration defined
7. OpenStack IaaS
   - 7.1 OpenStack IaaS
   - 7.2 OpenStack release timeline
8. OpenStack Architecture
   - 8.1 Conceptual architecture
   - 8.2 OpenStack IaaS at a Service Provider
9. End of Course Assessment

View Curriculum
Welcome to SDN and NFV - Introduction

Software Defined Networking and Network Functions Virtualization are reshaping what networks look like and how they are managed, and are providing significant competitive advantages for those providers who understand and deploy SDN and NFV based solutions. These solutions can improve customer response time and customer satisfaction, reduce errors and provide dynamic solutions that can automatically adjust to customer needs. This self-paced eLearning course provides a high-level understanding of the potential impact of SDN and NFV. It focuses on the business drivers behind the technology and an introduction into what is SDN and NFV without diving into too many details.

Intended Audience

The course is intended for all that are interested in understanding what are SDN and NFV, what are some key drivers, benefits and what the journey to SDN and NFV may look like.

Objectives

After completing this course, the student will be able to:
- Summarize key drivers behind SDN and NFV
- Explain the fundamental shift that SDN and NFV enables
- Describe SDN and NFV each in a sentence
- Describe the differences between an SDN and NFV-based solution and a traditional approach
- Identify some key challenges involved with implementing SDN and NFV on a large scale

What You Can Expect

- Self-Paced Duration: 0.5 HOUR

Outline

1. The Why and What of SDN and NFV
   1.1 Why SDN and NFV
   1.2 What is SDN and NFV
   1.3 Impact to network operator
   1.4 SDN and NFV drivers

2. SDN and NFV
   2.1 The SDN and NFV shift
   2.2 NFV
   2.3 Define in Nine
   2.4 NFV at a Glance
   2.5 SDN
   2.6 Define in Nine
   2.7 SDN in actions
   2.8 Terminology and concepts

3. Benefits and Journey
   3.1 Key benefits
   3.2 Getting to SDN and NFV
Welcome to SDN and NFV - Foundations

Where did this technology shift come from? The enterprise IT space has made a dramatic shift with Web-scale IT, virtualization, DevOps, open source software and decomposing IT applications into smaller components to enable scaling. These same concepts are now moving into the network provider space and are the foundation for leveraging SDN and NFV. This foundations module will focus on understanding the new software paradigm, virtualization, DevOps, open source culture and application development approach.

Intended Audience

The course is intended for all that are interested in understanding the foundational concepts underlying SDN and NFV.

Objectives

After completing this course, the student will be able to:
- Describe the power of software and the impact of virtualization
- Explain the concept of a Virtual Machine
- Define cloud computing and list its five key attributes
- Discuss the concepts of DevOps, open source software and Web-scale application development
- Differentiate between traditional service definition and cloud orchestration
- Relate the benefits of OpenStack

What You Can Expect

- Self-Paced Duration: 1 HOUR
- Prerequisite: Welcome to SDN and NFV - Introduction (eLearning)

Outline

1. Virtualization and Cloud Computing
   1.1 Define-in-Nine: Virtualization
   1.2 Define-in-Nine: Cloud Computing
   1.3 Key attributes of Cloud Computing
   1.4 Virtual Machines (VM)
   1.5 Containers

2. A New Approach to Software
   2.1 The shift towards software
   2.2 Open Source software
   2.3 Define-in-Nine: DevOps
   2.4 Decomposing application software for rapid scaling
   2.5 Bringing it together to achieve web-scale solutions
   2.6 Example: Web server

3. Cloud Orchestration
   3.1 On-demand Cloud services
   3.2 Define-in-Nine: Orchestration
   3.3 Inter-Cloud
   3.4 Creating flexible networks
   3.5 OpenStack

View Curriculum
Welcome to SDN and NFV - Technologies

Software Defined Networking (SDN) and Network Functions Virtualization (NFV) technologies are reshaping how telecom service providers’ networks operate resulting in more efficient operation that reduces costs and increases savings. Together, these solutions allow networks to operate at web-scale and provide customers with unprecedented levels of agility and flexibility.

Intended Audience
The course is for an audience interested in understanding how SDN and NFV provide optimal network solutions that not only provide customers with key benefits, but also improve the ability to respond to customer demands.

Objectives
After completing this course, the student will be able to:
- Give examples of SDN and NFV in action
- Sketch an example of an SDN and NFV-based network
- Articulate how orchestration provides improved network management
- Explain how SDN, orchestration and NFV work together to improve the customer experience
- List some of the fundamental shifts due to SDN and NFV

What You Can Expect
- Self-Paced Duration: 1 HOUR
- Prerequisite: Welcome to SDN and NFV - Foundations (eLearning)

Outline
1. Today’s and Tomorrow’s Networks
   1.1 Complexity of today’s service provider’s network
   1.2 Physical and virtual network functions
   1.3 Conceptual model of tomorrow’s network
   1.4 Key concepts of Software-Defined Network
2. NFV and SDN
   2.1 NFV and SDN working together
   2.2 NFV
   2.3 NFV at a glance
   2.4 NFV in action
   2.5 NFV framework
   2.6 Benefits of NFV
   2.7 SDN
2.8 SDN at a glance
2.9 SDN framework
2.10 SDN controller and apps
2.11 Benefits of SDN
3. Automating the Network
   3.1 NFV orchestration at a glance
   3.2 Dynamic capacity scaling
   3.3 Service function chaining
4. Walkthroughs: Fine Dining and the Network
5. Applying SDN and NFV to Tomorrow’s Network
   5.1 New paradigms
   5.2 Fundamental shifts
Technology Primer: Containers and Microservices in Telecom

Many forward-looking leaders recognize that the technological functions we use on a daily basis can be virtualized and moved to a cloud computing environment. This class surveys the topic of containers and microservices along with their applications and their implementations used in the industry. The student will learn about the concept of containers and microservices as well as their use cases and landscape.

**Intended Audience**
A high-level technical overview to personnel involved in product management, marketing, planning, design, engineering, and operations.

**Objectives**
After completing this course, the student will be able to:
- Differentiate between light weight and heavy weight virtualization
- Describe software container
- Describe key use cases for software containers
- Describe key use cases for software micro-services
- Identify the key container life-cycle management concepts
- Step through the examples of uses of micro-services

**What You Can Expect**
- Expert-Led Live Duration: 4 HOUR
- Prerequisite: Technology Primer: Cloud and Virtualization (Instructor Led)
- Prerequisite: Technology Primer: NFV (Instructor Led)

**Outline**
1. Introduction to Containers
   1.1 Types of virtualization
   1.2 Container architecture
2. Container Landscape
   2.1 Technology landscape
   2.2 Use cases
3. Container and Microservices
   3.1 Microservice architecture
   3.2 Microservices use cases
4. Container Orchestration
   4.1 Container Orchestration landscape
   4.2 Container life-cycle management
5. Putting It All Together
   5.1 Container example
   5.2 Microservice example

View Curriculum
Technology Primer: VxLAN and Segment Routing

VxLAN is a data plane encapsulation technique and Segment Routing is a label distribution mechanism which are popularly used in Network Virtualization. Service Provider networks and data centers extensively leverage server virtualization for flexibility, scalability and efficiency in compute resource use. To gain all the benefits of server virtualization it should go hand-in-hand with network virtualization. This course provides a conceptual understanding of the benefits, capabilities and high-level operations of VxLANs and Segment Routing in the context of Network Virtualization.

Intended Audience
This course is designed for an audience who needs to develop a high-level technical understanding of VxLANs and Segment Routing.

Objectives
After completing this course, the student will be able to:
- List the motivations behind using VxLANs and Segment Routing
- Describe VxLAN protocol
- Describe VxLAN operations
- Describe Segment Routing protocol
- Describe Segment Routing operations
- List Use Cases for use of VxLANs and Segment Routing

What You Can Expect
- Expert-Led Live Duration: 4 HOUR

Outline
1. Motivations
   1.1 VxLAN defined
   1.2 Segment Routing defined
   1.3 What problem do these technologies solve?
   1.4 Infrastructure versus Tenant networks

2. VxLAN
   2.1 Configuration
   2.2 Operations
   2.3 Protocols involved
   2.4 Intra-data center use case
   2.5 Inter-data center use case

3. Segment Routing
   3.1 Segment Routing – IPv6 and MPLS
   3.2 Configuration
   3.3 Operations
   3.4 Intra-data center use case
   3.5 Inter-data center use case
   3.6 Core network use case

4. Use Cases
   4.1 EVPN (Ethernet VPN using BGP)
SDN and NFV Architecture and Operations

Network Functions Virtualization (NFV) standards are still evolving as the telco industry grapples with this significant technology transformation. Software-Defined Networking (SDN) is a relatively new concept within the telco industry and has recently gained traction. NFV proposes to leverage standard IT virtualization technology to consolidate network equipment types onto industry standard high-volume servers, switches and storage. SDN proposes to take the traditional implementation of the networking and dis-assemble it. SDN is a collection of technologies that split the data, control and management planes of the network. The course provides a technical overview of NFV and SDN – in terms of the architecture, requirements, challenges, operations, and management – and how they relate and complement one another.

Intended Audience

This course is intended for a personnel in engineering and operations roles who are looking for a technical introduction to Network Functions Virtualization (NFV) and Software-Defined Networking (SDN).

Objectives

After completing this course, the student will be able to:
- Sketch the NFV reference architecture and building blocks
- Sketch end-to-end operational scenarios for vEPC, vCPE
- Identify the Key NFV requirements and benefit
- Discuss the role and performance aspects of the virtualization layer
- Define the NFV building blocks: Virtualization of Compute, Network and Storage
- Show how OpenStack can be an NFV VIM
- List and describe performance enhancements techniques
- Sketch the SDN architecture

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Technology Primer: Cloud and Virtualization (Instructor Led)
- Prerequisite: Technology Primer: NFV (Instructor Led)

Outline

1. SDN and NFV Architecture
   1.1 SDN architecture and Principles
   1.2 NFV, VNF
   1.3 EMS, OSS and BSS
   1.4 MANO

2. NFV Infrastructure
   2.1 NFV infrastructure deployment
   2.2 OpenStack components
   2.3 Heat and infrastructure Orchestration
   2.4 NFVI Domain
   Exercise: Lab: OpenStack

3. NFV Application - VNF
   3.1 VNF functional architecture
   3.2 VNF composition, VNF states
   3.3 Virtual functions software options
   3.4 VM live migration

4. NFV Management - MANO
   4.1 Orchestrator, Catalog
   4.2 Network service creation
   4.3 NFV descriptors
   4.4 Onboarding
   4.5 Lifecycle management
   4.6 VNF forwarding graphs
   Exercise: Lab: Management and Orchestration Demo

5. NFV Deployment Scenarios
   5.1 NFV service models
   5.2 Use Case for NFV deployment
   5.3 vIMS, vEPC, vPE

6. Deployment Considerations
   6.1 Life of data packet
   6.2 Performance
   6.3 DPDK and SR-IOV
   6.4 Scheduling and OS enhancements
   6.5 Elasticity and scaling in NFV

7. SDN Controllers
   7.1 SDN Ppanes and functions
   7.2 OpenFlow protocol
   7.3 SDN controller deployment options

8. SDN Protocols and Interworking
   8.1 NETCONF and YANG
   8.2 SDN for transport and WAN networks
   8.3 WAN interworking protocols
   Exercise: Lab: SDN Controller Demo

9. Network Orchestration with SDN
   9.1 Intra-Data center
   9.2 Integration with VIM
   9.3 Inter-Data center

View Curriculum
Containerized Network Functions Essentials

The 5G network has been designed to better support containerization. Containerized Network Functions allow for higher capacity, but they have a number of challenges around networking, performance, isolation, and orchestration. The course provides a high-level introduction to deploying a containerized network – in terms of the architecture, requirements, challenges, operations, and management – and how they relate and complement one another.

Intended Audience

This course is intended for personnel who are looking for a high-level introduction to Containerized Network Functions and Kubernetes/Docker-based cloud environments.

Objectives

After completing this course, the student will be able to:

- Discuss applications of containerized network functions (i.e. 5G)
- Compare Private, Public, and Hybrid cloud options
- Identify key service deployment considerations
- Discuss the role of containerization on networks (i.e. 5G)
- Define networking challenges of containerization
- List and describe Containerized NF Life Cycle Management

What You Can Expect

- Expert-Led Live Duration: 8 HOUR

Outline

1. Network Virtualization Architecture
   1.1 5G Core and Edge network as a use case
   1.2 Container and VM based Network Functions
   1.3 Orchestration

2. Virtualized Infrastructure
   2.1 Private vs public vs hybrid cloud
   2.2 Kubernetes, Docker
   2.3 AWS, Azure as public cloud options
   2.4 Networking considerations
   2.5 Storage considerations
   2.6 Security considerations

3. Network Functions Virtualization
   3.1 Service Based Architecture
   3.2 Containerized NFs
   3.3 Microservices
   3.4 Comparing to Virtual Machine Based NFs

4. Service Deployment Considerations
   4.1 System level performance
   4.2 Reliability, Scalability, Monitoring
   4.3 Orchestrator requirements
   4.4 Life Cycle Management
Containerized Network Functions Architecture and Operations

The 5G network has been designed to better support containerization. Containerized Network Functions allow for higher capacity, but they have a number of challenges around networking, performance, isolation, and orchestration. The course provides a technical overview of deploying a containerized network – in terms of the architecture, requirements, challenges, operations, and management – and how they relate and complement one another. Containerized network functions use cases are used to explore the different options that are available in the containerized world. The course enables hands-on practice of some key concepts.

Intended Audience

This course is intended for personnel in engineering and operations roles who are looking for a technical introduction to Containerized Network Functions and Kubernetes/Docker based cloud environments.

Objectives

After completing this course, the student will be able to:
- Describe applications of containerization (i.e. 5G)
- Compare Private, Public, and Hybrid cloud options
- Identify key service deployment considerations
- Discuss the role of containerization on networks (i.e. 5G)
- Define network functions and network slice microservice deployment scenarios
- Define networking challenges of containerization
- List and describe Containerized NF Life Cycle Management
- Hands-on demonstration of some key containerized deployment concepts

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Virtualization Basics
- Prerequisite: 5G Networks and Services Concepts

Outline

1. Network Virtualization Architecture
   1.1 5G Core and Edge network as a use case
   1.2 Network service templates
   1.3 Container and VM based Network Functions
   Exercise: Mini-Lab1: Lab-Setup

2. Virtualized Infrastructure
   2.1 Private vs public vs hybrid cloud
   2.2 Kubernetes, Docker
   2.3 AWS, Azure
   2.4 OpenStack
   2.5 Storage considerations
   2.6 Security considerations
   Exercise: Mini-Lab2: Docker Containers

3. Service Deployment Considerations
   3.1 System level performance considerations
   3.2 Container based performance considerations
   3.3 VM based performance considerations
   3.4 Container Engineering and Automation
   3.5 DPDK and SR-IOV considerations
   Exercise: Mini-Lab3: Docker Containers Resources

4. Network Functions Virtualization
   4.1 Service Based Architecture
   4.2 Containerized NFs
   4.3 Microservices
   4.4 Design Attributes (State, Persistency, etc.)
   Exercise: Mini-Lab4: Build & deploy containers with an app

5. Networking Considerations
   5.1 Networking with Containers
   5.2 Networking with Kubernetes
   5.3 Role of SDN in Container Networking
   Exercise: Mini-Lab5: Container Networking

6. Orchestration and Deployment
   6.1 Kubernetes Orchestration Overview
   6.2 Packaging
   6.3 Instantiation
   6.4 Life Cycle Management
   Exercise: Optional: Mini-Lab6: Networking, Deployment

View Curriculum
OpenStack Workshop for SDN and NFV

Competitive advantages of business agility drives the need for responsive and flexible IT infrastructure; which can be slow and expensive. The lead time to procure, install, configure, and commission new HW can take weeks. Cloud Computing IaaS brings speed, agility, scalability, and availability with lower CapEx and OpEx. This hands-on workshop is conducted in a Production Communication Service Provider context and the role OpenStack plays in NFV and SDN networks. Hands-on operational exercises are provided with detailed explanations of OpenStack’s component implementation, along with basic troubleshooting. Participants become Tenants and create multi-tiered network topologies and web service applications, enabling the participant to more adeptly deploy and support Cloud applications in an IaaS environment.

Intended Audience
A hands-on in-depth technical training to personnel involved in design, engineering, and operations and monitoring telecom networks.

Objectives
After completing this course, the student will be able to:
- OpenStack’s role in NFV and SDN networks
- Identify the benefits and applications of IaaS and OpenStack
- Diagram OpenStack’s logical and physical architectures
- Provision, manage, and monitor resource pools in a Cloud Computing Center
- Create simple virtual network over OpenStack IaaS
- Explore OpenStack features such Snapshot, etc.
- Contrast the benefits and considerations of cloud deployments
- Cloud partitioning over physical host deployments

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Technology Primer: Cloud and Virtualization (Instructor Led)
- Prerequisite: Technology Primer: NFV (Instructor Led)

Outline

1. Prologue
   1.1 Cloud computing
   1.2 Role of OpenStack in NFV and SDN Networks
   1.3 OpenStack services highlights
      Exercise: OpenStack Lab Setup

2. OpenStack IaaS
   2.1 OpenStack components and architecture, and supporting systems
   2.2 OpenStack services on physical hosts and physical networks
   2.3 Cloud segregation techniques
      Exercise: Lab: Horizon (Dashboard)

3. Identity Service (Keystone)
   3.1 Keystone concepts
   3.2 Keystone authentication and authorization policy enforcement.
   3.3 Keystone database and service catalogue
      Exercise: Lab: Identity Service (Keystone)

4. Compute Service (Nova)
   4.1 Nova capabilities, components and service daemons
   4.2 Nova under-the-hood VM provisioning trace
   4.3 Scheduler and filter algorithms
      Exercise: Lab: Compute Service (Nova)

5. Image Service (Glance)
   5.1 Glance capabilities and concepts
   5.2 Glance services
      Exercise: Lab: Image Service (Glance)

6. Networking Service (Neutron)
   6.1 Networking capabilities, components and service agents
   6.2 Network use cases
   6.3 Under-the-hood implementation
   6.4 Network frame trace
      Exercise: Lab: Network Service (Neutron)

7. Block Storage Service (Cinder)
   7.1 Cinder overview
   7.2 Cinder architecture
   7.3 Cinder volume management
      Exercise: Lab: Block Storage Service (Cinder)

8. Object Service (Swift)
   8.1 Swift capabilities, architecture and service daemons
   8.2 Account, Container, Object Walk-Through
   8.3 Swift deployment considerations
      Exercise: Lab: Object Storage Service (Swift)

9. Telemetry and Alarm Services
   9.1 Capabilities, components and services
      Exercise: Lab: Telemetry and Alarming Service

10. Orchestration (Heat)
    10.1 Capabilities, components and service daemons
    10.2 Heat Stack templates
        Exercise: Lab: Orchestration (Heat)
Container Workshop Using Docker

Virtualization keeps on advancing. The industry is trending towards more containers and serverless deployment options. The students learn about the concepts of containers as well as their use cases and landscape. This course is a hands-on workshop enabling students to practice discussed topics of containers and some container orchestration. The course explores the networking options for containers. Students also practice the container orchestration and management. The concepts in the course are solidified through a series of exercises so the students can experience firsthand how containers are used, supported, and orchestrated.

Intended Audience
This course is designed for professionals in the industry who plan, engineer, and deploy the cloud infrastructure and need to understand Software Containers.

Objectives
After completing this course, the student will be able to:

■ Differentiate between light weight and heavy weight virtualization
■ Describe software containers
■ Describe networking options for containers
■ Describe key use cases for software containers
■ Describe container orchestration options such as Kubernetes, Docker, Swarm, Apache Mesos
■ Practice container deployments
■ Practice container orchestration
■ Illustrate container Life Cycle Management

What You Can Expect
■ Expert-Led Live Duration: 24 HOUR
■ Prerequisite: Introductory knowledge of Linux
■ Prerequisite: Technology Primer: Cloud and Virtualization
■ Required Equipment: Student computing device, i.e. laptop

Outline

1. Overview of Containers
   1.1 Types of Virtualization
   1.2 Container Security
   1.3 Container Runtime Engine and Images
   1.4 Container Repositories
   1.5 Cloud Tolerant vs. Cloud Native
      Exercise: Deploy Containers, Security Options, Image Layers

2. Container Use Cases and Landscape
   2.1 Use cases
   2.2 Microservice
   2.3 Container landscape
      Exercise: Containerized applications

3. Containers and Networking
   3.1 Container Networking Options
   3.2 Bridge Mode
   3.3 Networking for Virtualization
      Exercise: Containers networking options

4. Container Orchestration
   4.1 Containers and Orchestration
   4.2 Container Orchestration landscape
   4.3 Overview of Kubernetes
      Exercise: Container Orchestration

5. Additional Labs
   Exercise: Hands-on Lab(s)

View Curriculum
Container Orchestration Workshop

Competitive advantages of business agility drives the need for responsive and flexible IT infrastructure; which can be slow and expensive. The lead time to procure, install, configure, and commission new HW can take weeks. Containerization brings speed, agility, scalability, and availability with lower CapEx and OpEx. This hands-on workshop is conducted in a Production Communication Service Provider context and the Containers plays in NFV and SDN networks. Hands-on operational exercises are provided with detailed explanations of Kubernetes component implementation, along with basic troubleshooting. Participants become Tenants and create multi-tiered network topologies and web service applications, enabling the participant to more adeptly deploy and support Containerized applications in a Kubernetes environment.

Intended Audience
A hands-on in-depth technical training to personnel involved in design, engineering, and operations and monitoring telecom networks.

Objectives
After completing this course, the student will be able to:
- Describe Container Orchestration
- Identify applications of Kubernetes in NFV
- Describe Kubernetes physical architectures
- Provision, manage and monitor Kubernetes resources
- Create simple virtual network
- Explore Kubernetes Services
- Contrast the benefits of Networking Options
- Deploy and Update Pods using Repos

What You Can Expect
- Expert-Led Live Duration: 24 HOUR
- Prerequisite: Introduction to Software Containers Workshop
- Required Equipment: Computer with admin privileges

Outline

1. Prologue
   1.1 Cloud computing
   1.2 Role of Containers in NFV and SDN
   1.3 Kubernetes services highlights
      Exercise: Kubernetes Lab Setup

2. Container Cloud Infrastructure
   2.1 Kubernetes components and architecture
   2.2 Kubernetes physical hosts and networks
   2.3 Tenant segregation techniques
      Exercise: Kubernetes Dashboard

3. Deployment of Pods
   3.1 Kubernetes capabilities and components
   3.2 Pod Deployment & provisioning trace
   3.3 Scheduler and filter algorithms
      Exercise: Pod Deployment

4. Networking Services
   4.1 Networking capabilities and components
   4.2 Network use cases
   4.3 Under-the-hood implementation
   4.4 Network frame trace
      Exercise: Network Services

5. Using Repos
   5.1 Repos capabilities and concepts
   5.2 Repos services
   5.3 Kubernetes and DevOps
      Exercise: Using Repos

6. Kubernetes Services
   6.1 Kubernetes Services
   6.2 Using Kubernetes Services
      Exercise: Deploy Kubernetes Services

View Curriculum
TOSCA and YANG Workshop

Service modeling is a challenging area within the virtualized world. There are multiple languages that could be used to model services and no standard has been agreed upon in the industry. This hands-on workshop is broken into three key parts. The first is a brief overview of NFV and modeling in general. Parts two and three are a deep dive into each of the modeling languages of YANG (Yet Another Next Generation) and TOSCA (Topology and Orchestration Specification for Cloud Applications). Each language will be examined based on its basic structure, key features, extensibility, maturity, and use in the industry. For each modeling language, there are a number of hands-on exercises to support understanding of the basics and the key features of each of these three languages.

Intended Audience

This hands-on course is designed for teams that are developing and deploying services in a virtualized network.

Objectives

After completing this course, the student will be able to:
- List the key requirements of service modeling
- Apply YANG modeling to describe services
- Identify components of a YANG model
- Apply TOSCA modeling to describe services
- Identify components of a TOSCA model

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: OpenStack Workshop for SDN and NFV

Outline

1. Introduction of Services and Modeling
   1.1 ETSI descriptor dissection
   1.2 Service Requirements
   1.3 Modeling Languages Comparison
      - Exercise: Lab access and setup
2. YANG Data Models
   2.1 Need for data modeling in Telecom
   2.2 YANG data modeling
   2.3 YANG model components
      - Exercise: Create a YANG model
3. Analyzing YANG
   3.1 YANG and PYANG
   3.2 YANG Tree Structure
   3.3 YANG Pictorial Representations
      - Exercise: Examine Industry Examples of YANG

4. TOSCA Data Modeling
   4.1 Background of TOSCA
   4.2 Overview of TOSCA
   4.3 TOSCA data modeling
   4.4 TOSCA model components
      - Exercise: Examine and execute TOSCA templates
   4.5 TOSCA Orchestrators

5. TOSCA Model Details
   5.1 Types and Templates
   5.2 TOSCA Dependencies
   5.3 TOSCA Extensibility
      - Exercise: Create a TOSCA model
      - Exercise: Examine Industry Examples of TOSCA
NETCONF/YANG Configuration Workshop

Network configuration tools are increasingly important as more network services move to the cloud. SNMP is being superseded by NETCONF (Network Configuration Protocol) and the associated YANG (Yet Another Next Generation) standard. Network operating center workflows will change as we move toward configuration with NETCONF. In this class, the student will update and implement YANG data models and use NETCONF configuration. We will also use YANG modeling for network service and Virtual Network Functions (VNF) models in NFV.

Intended Audience

This hands-on course is designed for network operations, planning, engineering, management or other related functions.

Objectives

After completing this course, the student will be able to:
- Apply YANG modeling and NETCONF to NFV and SDN networks
- Identify components of a YANG model
- Discuss NETCONF and its relationship to YANG
- List alternatives to NETCONF
- Describe, update, and build a YANG data model for an NFV network service and VNFs
- Differentiate between NETCONF usage for configuration management and control plane
- Demonstrate Importing data models and running NETCONF configuration
- Utilize the tools used to perform various network functions and device configuration

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: OpenStack Workshop for SDN and NFV (Instructor Led)
- Prerequisite: SDN and NFV Architecture and Operations (Instructor Led)
- Required Equipment: It is highly recommended that students use more than one monitor for this workshop

Outline

1. NETCONF/YANG for NFV and SDN Networks
   1.1 Role of NETCONF/YANG in Virtualized Networks
   1.2 NETCONF for network management
   1.3 TOSCA vs YANG
   Exercise: Lab: Northbound interface auto rendering

2. YANG Data Models
   2.1 Need for data modeling in Telecom networks
   2.2 YANG data modeling
   2.3 YANG model components
   Exercise: Lab: Create a YANG model

3. YIN XML
   3.1 YANG-YIN conversion process
   3.2 XML structure highlights
   3.3 YANG to YIN
   Exercise: Lab: YANG to YIN, and other YANG model viewing options

4. NETCONF vs. SNMP
   4.1 Role of SNMP
   4.2 NETCONF vs SNMP

5. NETCONF
   5.1 Purpose of NETCONF
   5.2 NETCONF features
   5.3 NETCONF layers
   Exercise: Lab: NETCONF datastores

6. NETCONF Operations
   6.1 NETCONF protocol handshake
   6.2 NETCONF datastores
   6.3 Main NETCONF operations
   6.4 NETCONF server discovery
   Exercise: Lab: NETCONF operations

7. YANG for NFV
   7.1 NFV data modeling
   7.2 YANG modeling for NFV

What You Can Expect

- Expert-Led Live Duration: 24 HOUR
- Prerequisite: OpenStack Workshop for SDN and NFV (Instructor Led)
- Prerequisite: SDN and NFV Architecture and Operations (Instructor Led)
- Required Equipment: It is highly recommended that students use more than one monitor for this workshop

View Curriculum
Accelerating Digital Transformation

Companies are understanding that they need to rethink various parts of their business, or face competitors who are leveraging technology to be more efficient, more agile, and more valuable to customers. But transforming an existing company comes with a variety of challenges, from developing a vision to implementing an execution strategy that might include transforming legacy systems and processes, many of which have been used successfully for years, even decades. This comes with the challenge of helping a talented workforce learn to think differently, and understand and embrace new technologies like never before. This workshop helps leaders develop a common language and vision for transformation within and across their organizations, better understand the power of various transformational technologies, and begin formulating an action plan.

Intended Audience
Teams within organizations who would like to accelerate their transformation, from strategic leadership teams to functional organizations

Objectives
After completing this course, the student will be able to:

■ Speak a common language around Digital Transformation within your organization
■ Describe the current state of digital transformation within your organization
■ Articulate areas of transformational focus, and prioritize them based on potential for impact
■ Identify the role of technologies like AI, IoT, and wireless (4G-5G) in your transformation journey
■ Give concrete, relevant examples of how other companies have benefitted from transformation
■ Give examples where transformational attempts were not successful, and explain why
■ List potential challenges as your organization transforms, and offer ideas for addressing them
■ Articulate a set of next steps for implementing transformation in your organization

What You Can Expect
■ Expert-Led Live Duration: 8 HOUR

Outline

1. The Transformation Imperative
   1.1 What is digital transformation?
   1.2 What is driving the transformation?
   1.3 A transformed customer experience
   1.4 Benefits of transformation
   1.5 How urgent is it?
   Exercise: The customer journey

2. Transformational Technologies: Data and Insights
   2.1 The power of insights
   2.2 Driving toward actionable insights
   2.3 Moving from data to decisions
   2.4 Visualizing well
   2.5 Influencing through analytics
   2.6 Examples & challenges
   Exercise: Visualization & Insights

3. Transformational Technologies: Automation
   3.1 The power of automation
   3.2 Automation: Scope and impact
   3.3 Automation technologies
   3.4 Automation in action
   3.5 Examples & challenges
   Exercise: Exploring Automation

4. Transformational Technologies: AI
   4.1 The power of AI
   4.2 Machine Learning
   4.3 Machine Learning frameworks
   4.4 Machine Learning in action
   4.5 Examples & challenges
   Exercise: Exploring AI

5. Transformational Vision
   Exercise: Trapped value
   5.1 Developing a vision for transformation
   5.2 Examples of successful transformations
   Exercise: Transformational vision

6. Implementing transformation
   6.1 Key success factors for transformation
   6.2 Typical challenges for transformation
   6.3 Avoiding typical missteps
   Exercise: Discussion: Anticipating challenges

7. Plan: Next steps
   Exercise: Transformation priorities
   7.1 Next steps

Modules 2, 3, or 4 can be replaced with modules on IoT, 5G, or Software Development if desired.
Network Virtualization Workshop for Leaders

This experiential workshop helps participants grapple with and better understand the essentials of network virtualization. A large portion of the day is spent hands-on, building and discussing network architecture models and technology concepts. Key architecture posters provide aids for building exercises as well as discussions. Participants discuss current network challenges and KPIs, changes being made to virtualize the network, and how these changes are solving today’s challenges, while possibly introducing new ones. The course flow follows the virtualization layer model, beginning with the physical infrastructure and moving through the virtualization layer and application layer and finally the service (orchestration) layer. Leaders will be better prepared to make strategic decisions, given a more dynamic and virtual network infrastructure.

Intended Audience

This course is designed for an audience to understand why service providers are virtualizing their networks, the challenges virtualization solves, key technologies and terminology, and fundamental shifts of this move.

Objectives

After completing this course, the student will be able to:

■ Describe the challenges with today’s network architecture
■ Sketch and describe the key components of a virtualized network
■ List key benefits of a virtualized network
■ Illustrate how virtualization technologies are solving some of today’s key challenges
■ List some important shifts that will occur with network virtualization

What You Can Expect

■ Expert-Led Live Duration: 8 HOUR

Outline

1. Today’s network
   Exercise: Challenges and KPIs

2. The Physical Infrastructure Layer
   2.1 Physical Network Functions and Virtual Network Functions
      Exercise: Build a Physical Network Function and convert it to a virtual one
   2.2 Virtualized Networks
   2.3 Cloud NFV Infrastructure
      Exercise: Build local data center – understand the core of a virtualized network

3. Virtualization Layer
   3.1 Why Virtualization?
   3.2 Virtual Machines
      Exercise: Build a physical server with a virtual machine
      Exercise: Model a Physical Infrastructure Manager and a Virtual Infrastructure Manager

4. Application Layer
   4.1 Components of a Virtual Network Function
      Exercise: Model Virtual Network Functions, managers and descriptors
   4.2 Software-Defined Network
      Exercise: Software-Defined Networking – Build a router
   4.3 SDN in a virtualized network

5. Orchestration
   5.1 What is orchestration?
   5.2 Life of a network service

6. Virtualized Network: Putting It All Together
   Exercise: Discuss key takeaways

View Curriculum
Thank You