Teracom Training Institute
Certified Telecommunications Network Specialist (CTNS) Certification Package

Invest in yourself with Teracom's CTNS Certification Package, six online courses giving you a solid foundation in telecom, datacom and networking, from traditional telephony and cellular to Ethernet, IP and MPLS networking, understanding the fundamentals, technologies, jargon and buzzwords, and most importantly, the underlying ideas and how it all fits together… plus Telecommunications Certification Organization (TCO) Certified Telecommunications Network Specialist (CTNS) Certification to prove it.

Benefit from decades of knowledge, insight and experience distilled into clear lessons, logically organized to build one concept on another. Get a major career-enhancing and productivity-enhancing knowledge upgrade – learning that you can't get on the job, reading magazines or talking to vendors… solid understanding that lasts a lifetime.

The CTNS Certification Package begins with the Public Switched Telephone Network, as understanding the structure and operation of the network built over the past 135 years is a starting point for understanding everything else. This is followed by Wireless Telecommunications, with mobile from radio and cellular principles to 5G and Wi-Fi 6.

Then four courses on IP telecom provide a practical understanding of Ethernet LANs, VLANs, IP and MPLS, and how these technologies work together to implement a converged network carrying phone calls, video and Internet traffic on a single network. We begin with the OSI Reference Model as a framework.

Each course has an exam consisting of ten multiple-choice questions. Passing the course exams proves your knowledge and results in your certification as a Certified Telecommunications Network Specialist. You'll get a full-color TCO Certificate suitable for framing, plus a personalized Letter of Introduction / Letter of Reference introducing you and explaining the knowledge your Certification represents.

Your investment is protected with a 30-day, 100% money-back guarantee.
Get started now!

Certified Telecommunications Network Specialist (CTNS) Package Overview

The CTNS package begins with Course 2201 The PSTN. We begin that course with a history lesson, understanding how and why telephone networks and the companies that provide them are organized into local access and inter-city transmission, or as we will see, Local Exchange Carriers (LECs) and Inter-Exchange Carriers (IXCs).

The structure, components and operations described in this course were built worldwide, in every country on earth, during the period 1970 - 2000. Though its circuit-switching has been eclipsed by IP packet switching, all of the new technologies must be integrated with the old. To this day, understanding PSTN channels and circuit-switching is necessary to know how a phone call from a cellphone on a wireless network connects to a phone plugged into a competitor's cable modem in another city.

We will establish a basic model for the PSTN and understand its main components: Customer Premise, Central Office, loop, trunk, outside plant, circuit switching, attenuation, loop length, remotes.

Next, we'll cover aspects of telephony and Plain Ordinary Telephone Service, including analog, the voiceband, twisted pair, supervision and signaling including DTMF. The course is completed with an overview of SS7, the control system for the telephone network in the US and Canada.

On completion of this course, you will be able to draw a model of the PSTN, identify all of its components and technologies from voiceband analog to fiber to the neighborhood, and explain the characteristics and operation of POTS, the principal service.

Course 2206 Wireless Telecommunications, a comprehensive course on wireless, including radio fundamentals, cellular and mobile telecommunications plus Wi-Fi and more. Fully up-to-date for the 2020s with 5G, Wi-Fi 6 (802.11ax) and Starlink.

We begin with basic concepts and terminology involved in mobile networks, including base stations and transceivers, mobile switches and backhaul, handoffs, cellular radio concepts and digital radio concepts.

You'll understand how a phone call connects from a cell phone to a landline, and the different methods of allowing other devices to use a smartphone's mobile Internet connection.

Without bogging down on details, we'll review spectrum-sharing technologies: FDMA for first generation; 2G GSM/TDMA, 3G CDMA and 4G and 5G OFDM. We'll take some time to understand how modems represent bits on subcarriers, and how OFDMA is used in 4G and 5G to dynamically assign subcarrier(s) to users.

This is followed with Wi-Fi, or more precisely, 802.11 wireless LANs: the system components, frequency bands, bitrates and coverage for all of the versions up to Wi-Fi 6 which is 802.11ax, the first Wi-Fi to implement full-duplex communications with multiple simultaneous devices using OFDMA and a theoretical 9.6 Gb/s. We'll also cover WPA-2 and WPA-3 security.

The course is completed with communications satellites, in Geosynchronous Earth Orbit and Low Earth Orbit, including Iridium Next and Starlink.

The remaining four courses in the CTNS package are on the “IP” telecommunications network and its three main enabling technologies: Ethernet, IP and MPLS, and beginning with the OSI model and its layers to establish a framework.

Course 2212 The OSI Layers and Protocol Stacks establishes a framework for all of the subsequent discussions: the OSI 7-Layer Reference Model, which identifies and divides the functions to be performed into groups called layers. This framework is required to sort out the many functions that need to be performed, and to be able to discuss separate issues separately.

First, we’ll define the term “protocol” and compare that to a standard. Then we’ll define “layer” and how a layered architecture operates, and provide an overview of the name, purpose and function of each of the seven layers in the OSI model.

Then, we’ll go back through the story more slowly, with one lesson for each of the layers, examining in greater detail the functions that have to be performed and giving examples of protocols and how and where they are used to implement particular layers.

The result is a protocol stack, one protocol on top of another on top of another to fulfill all of the required functions. To make this more understandable, this course ends with the famous FedEx Analogy illustrating the concepts using company-to-company communications, and an analogy of Babushka dolls to illustrate how the protocol headers are nested at the bits level.

On completion of this course, you will be able to define a protocol and differentiate that from a standard, explain why a layered architecture is required, list the seven layers of the OSI model, the name, purpose and functions of each one, and explain how a protocol stack operates and where the protocol headers are located. Detailed description of Course 2212 The OSI Layers and Protocol Stacks begins on page 14.

Next is Course 2211 Ethernet, LANs and VLANs – which could be titled “Layer 2”.

As we will have established in the previous course, Layer 2 is all about communications between two devices that are on the same circuit, or more precisely, in the same broadcast domain. It turns out that this is implemented by moving frames with link addresses over physical connections following the 802 series of standards, colloquially referred to as Ethernet, MAC frames and MAC addresses.

We’ll begin with the original LAN: Ethernet and its bus topology, defining “broadcast domain” and explaining its fundamental operation and characteristics: CSMA-CD access control, MAC addresses and MAC frames.

Then we’ll cover the IEEE 802 standards and the evolution of Ethernet from 10BASE-T to Gig-E, LAN cables and the TIA-568 cable categories, basic cabling design; what "bridging" means and how a LAN switch works.

This course is completed with the important concept of VLANs: defining broadcast domains in software, a key part of basic network security practice.

On completion of this course, you will be able to define a broadcast domain, explain Ethernet and the 802 standards, MAC addresses, LANs and VLANs, the jargon and buzzwords, the underlying ideas, and how it all works together to move data between two devices in the same broadcast domain. Detailed description of Course 2211 Ethernet, LANs and VLANs begins on page 18.

Next is Course 2213 IP Networks, Routers and Addresses – which could also be titled “Layer 3” – a comprehensive course on Layer 3 of the OSI Model, concentrating on IP addresses, routers and packets.

We begin with the two basic principles of packet networks: bandwidth on demand, also known as overbooking or statistical multiplexing; and packet-switching, also known as packet forwarding or routing.

We’ll understand what routers do and where they are located, routing tables and the basic operation of a router and the standard strategy deploying an edge router between the LANs and the WAN at each location.

Then we’ll cover IP version 4: address classes and how they are assigned to Regional Internet Registries then ISPs then end-users, dotted-decimal notation, static addresses, dynamic addresses and DHCP, public addresses, private addresses and NAT.

The course concludes with IPv6: the IPv6 packet and changes from IPv4, IPv6 address allocations and assignments and end up understanding how IPv6 subnets will be assigned to broadcast domains and 18 billion billion addresses per residence.

On completion of this course, you will be able to define bandwidth on demand and its advantages, what a router does, the basic structure of a routing table, where routers are located, define the IPv4 address structure and dotted-decimal notation, explain how both static and dynamic addresses are assigned using DHCP, what private addresses are and how they are interfaced to the public IP network, and the structure, allocation and assignment of IPv6 addresses.

Detailed description of Course 2213 IP Networks, Routers and Addresses begins on page 21.

The last course in this certification package is Course 2214 MPLS and Carrier Networks. This is an extensive and comprehensive course devoted to the structure, components and operation of carrier packet networks and services, how they are implemented, packaged and marketed, and how they are used by government, business and other carriers.

The IP packets and routing of the previous course is one part of the story. Performance guarantees, and methods for quality of service, traffic management, aggregation and integration is another big part of the story, particularly once we leave the lab and venture into the real world and the business of telecommunications services.

We’ll begin by establishing a basic model for a customer obtaining service from a provider, defining Customer Edge, Provider Edge, access and core, and a Service Level Agreement: traffic profile vs. transmission characteristics.

Next, we’ll understand virtual circuits, a powerful tool used for traffic management and variations like connection-oriented vs. connectionless communications and reliable vs. unreliable network services.

With the fundamentals in place, we will survey the different technologies used to implement this in practice: Frame Relay, ATM and MPLS, explaining the equipment, jargon and principles of operation, and the advantages each technology has over the previous. In particular, we’ll understand the big advantage of MPLS over Frame Relay in the user-network interface.

Once we've covered all of the components of an MPLS network and its operation, we'll see how MPLS is used to implement Diff-Serv, i.e. different classes of service, how MPLS is used to implement integration or "convergence" of services onto a single network service, and how MPLS is used to aggregate traffic for management.

The course is completed with a lesson on "MPLS service", and how that compares to Internet service.

On completion of this course, you will be able to draw a model for a service provider's network, define the terms Customer Edge and Provider Edge, explain what a traffic profile is and how that relates to a Service Level Agreement, how Frame Relay got its name, what ATM is and why it is on the way out, the purpose, components, terminology and operation of MPLS, and how MPLS can be used to implement integration or convergence, aggregation and differentiated classes of service – what people mean when they say "MPLS service" and its pros and cons compared to Internet service.

Detailed description of Course 2214 MPLS and Carrier Networks begins on page 25.

Detailed Course Descriptions

Course 2201 The PSTN

Loops and Trunks • Circuit-Switching • LECs and IXCs • Analog • Voiceband • DTMF • SS7

8 interactive multipart lessons, multiple-choice exam and certificate. Produced 2020.

This course is dedicated to the Public Switched Telephone Network (PSTN) and Plain Ordinary Telephone Service (POTS).

One cornerstone of a full, rounded base of knowledge of telecommunications is the structure and operation of the Public Switched Telephone Network, built over the past 135 years, still in operation in every country on earth – knowledge necessary for connecting the PSTN to, and steadily replacing the PSTN with IP telecom technologies.

You'll gain a solid understanding of the fundamentals of the telephone system: customer premise and Central Office, loops, trunks, remotes, circuit switching and how a telephone call is connected end-to-end. We'll cover LECs and IXCs, sound, analog and the voiceband, twisted pair, DTMF and SS7.

Based on Teracom's famous Course 101, tuned and refined over the course of 20 years of instructor-led training, we'll cut through the jargon to demystify telephony and the telephone system, explaining the jargon and buzzwords, the underlying ideas, and how it all works together… in plain English.

Featuring many photos of actual equipment both inside a Central Office and in the outside plant, this multimedia course is an excellent way to get up to speed on traditional telephony.

Course Outline

1. Introduction
Course introduction and overview.

2. History of Telecommunications
Local phone companies, long distance; US: Bell System, breakup, LECs and IXCs; Canada

3. The Public Switched Telephone Network (PSTN)
Loops and trunks, CO, customer premise, circuit-switching, outside plant, loop length, remotes

4. Analog Circuits and Sound
What analog means, microphones and speakers, copper wires and electricity, sound: trees falling in the forest

5. The Voiceband
Reproducing thoughts vs. reproducing sound, frequency range, filters, limitations

6. Plain Ordinary Telephone Service (POTS)
Twisted pair, analogs on two wires, dial tone, ringing, supervision, lightning protection

7. Signaling: Pulse Dialing and DTMF
Dial-up, make-or-break signaling, touch-tone, DTMF, in-band signaling

8. Signaling System 7 (SS7)
Control system for the PSTN, SCPs and SSPs, call routing between carriers

Prerequisites

None.

Course Objectives: What You Will Learn

The objective of this course is to understand how the physical telephone network is organized, the characteristics of basic telephone service, how calls are established end-to-end, and to demystify common telephony jargon and buzzwords.

In particular, on completion of this course, you will be able to explain:

- Why telecom networks are divided into local access wiring and long-distance transmission
- The founding, breakup and re-emergence of AT&T in the US; TELUS and Bell in Canada
- A basic model for the PSTN and its main components
- Loops, why they are called loops and why there is a maximum loop length
- The outside plant
- Circuit-switching
- Central Office and Customer Premise
- How and why remotes are used; fiber to the neighborhood
- Plain Ordinary Telephone Service
- What analog is, and how it relates to copper wires, electricity, circuits and sound
- How microphones and speakers work
- The human hearing range
- Whether trees falling in the forest if no-one is there to hear them cause a sound
- The voiceband
- Why and how the telephone system can limit frequencies to the voiceband
- Why two wires are used
- Why they are twisted together (twisted pair)
- Tip and ring, -48 volts
- Supervision, dial tone, ringing, lightning protection
- Dial-up
- Touch-tone and DTMF
- Basics of SS7
- Examples of sophisticated call routing using SS7

Detailed Course Description

In this course, we'll understand the Public Switched Telephone Network (PSTN), and Plain Ordinary Telephone Service (POTS). Though Voice over IP, SIP and broadband Internet will eventually replace the PSTN and its circuit-switched, channelized and analog technologies, understanding POTS and the PSTN remains one of the cornerstones of a complete understanding of telecom.

Based on Teracom's famous instructor-led Course 101, tuned and refined over twenty years, this course will give you solid foundational knowledge that will be useful to anyone in the telecom business: how the physical telephone network is organized, the characteristics of basic telephone service, how calls are established end-to-end, and understanding of telephony jargon and buzzwords… in plain English.

It is tempting for newcomers to telecom to think "this is old stuff, we don't need to know this, it's all IP now"... but it is not difficult to come up with a list of reasons why understanding The PSTN is still necessary.

There are hundreds of millions of POTS lines and PBX trunks still in service, still being maintained and still generating revenue for carriers. This will not disappear overnight, but will continue to be supported for many years to come, until the last POTS line is disconnected. Broadband Internet service is provided using DSL modems over the wires put in place for POTS.

Even if we were to move to an all-Voice-over-IP network, at least the last foot will still be analog: at residences, a cable modem or fiber terminal performs the functions of a POTS line card: power, dial tones, ringing and analog signals to regular phones via the telephone wires inside the house. At a business, the analog-digital conversion might happen inside a VoIP telephone plugged onto the LAN - but the signals on the curly cord attached to the handset are analog.

Many VoIP systems digitize voice at 64 kb/s, a bit rate that is directly related to the voiceband defined for analog POTS. Legacy SONET and SDH fiber-optic transmission infrastructure are organized into 64 kb/s channels.

Understanding channels and circuit-switching is necessary to know how a phone call from a cellphone on a wireless network connects to a phone plugged into a competitor's cable modem in another city.

There is a huge inertia of regulations, tariffs, accounting and money involved in the Interconnect between local exchange carriers (the "last mile"), and competing inter-exchange carriers, (the "long distance"), that is based on Tandem Access Trunks, channelized PSTN circuit-switched technology.

Lesson 1. Course Introduction

The first lesson begins the course with an overview of the course and lessons.

This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the production quality.

Lesson 2. History of Telecommunications

We begin the course proper with a history lesson. We'll understand why telecom networks are divided into local access wiring and long-distance transmission, the invention of the telephone and Bell's patent and the emergence of local telephone companies. Then, in the USA: the founding of AT&T, the expiry of the patent and

emergence of independents, Federal government action against AT&T resulting in its breakup, the emergence of cellular and internet telephony, the end of long-distance as a standalone business and the re-combination of pieces of the former AT&T into AT&T and Verizon. An optional section on Canadian telecommunications covers the establishment of provincial telephone companies, then consolidation under TELUS and Bell Canada.

Lesson 3. The Public Switched Telephone Network (PSTN)
In this lesson, we will establish a basic model for the PSTN and understand its main components: Customer Premise, Central Office, loop, trunk, outside plant, circuit switching, attenuation, loop length, remotes, and why knowledge of the characteristics of the loop remains essential knowledge even though we are moving to Voice over IP.

Lesson 4. Analog Circuits and Sound
The technique for representing information on an ordinary local loop is called analog. This term is often thrown about with little regard for its actual meaning, so we will spend a bit of time understanding what is meant by “analog”, how this relates to copper wires, electricity, circuits and sound, the human hearing range, whether trees falling in the forest cause sound if there are no humans present, and choices for designing the telephone system related to that question.

Lesson 5. The Voiceband
In this lesson, we examine the bandwidth provided with Plain Ordinary Telephone Service, which is often referred to as *the voiceband*. We’ll understand what the term “bandwidth” means, and how it is measured in the analog world. We’ll look at the details of the voiceband, what frequencies it covers and why, and its limitations.

Lesson 6. Plain Ordinary Telephone Service
Loops, trunks, circuit-switching and the voiceband are all aspects of Plain Ordinary Telephone Service (POTS). In this lesson, we will cover the remaining principal aspects of POTS along with associated jargon and buzzwords including twisted pair, the function of the microphone, speaker and hybrid converter, how the voltage analogs for each direction are added together on the loop, supervision, loop-start signaling and ringing and lightning protection.

Lesson 7. Signaling: Pulse Dialing and DTMF
This lesson covers one last principal aspect of POTS: the mechanism for signaling the called party telephone number from the calling party’s telephone to the line card. We first cover the original design, using a rotary dial, then an improvement using tones called Dual Tone Multiple Frequency (DTMF) signaling.

Lesson 8. Signaling System 7 (SS7)
This lesson provides a top-level overview of the system used for signaling the called number from the near-end switch to the far-end switch, which is part of the call setup function. This called Signaling System 7 (SS7) in the USA and Canada. It is used for many functions in addition to call setup. In the rest of the world, other systems are used, including ISDN and proprietary systems. This lesson covers SS7, though the basic principles are applicable to any network signaling system.

Course 2206 Wireless Telecommunications

Mobile Network Fundamentals • Cellular Principles • Digitized Voice over Radio • Mobile Internet • FDMA, TDMA, CDMA and OFDM • 4G LTE and OFDMA • 5G: New Spectrum, Ultra-Broadband and IoT • Wi-Fi 6 802.11ax • Communication Satellites

10 interactive multipart lessons, multiple-choice exam and certificate. Produced 2020.

Wireless Telecommunications is a comprehensive up-to-date course on cellular plus Wi-Fi and satellites for non-engineering professionals.

Taking this course, you will develop a solid understanding of the fundamental principles of radio, mobility and cellular, network components and operation, digital radio, mobile phone calls and mobile Internet access, spectrum-sharing technologies like OFDM, and LTE and 5G. In addition, you will get up to speed on the components, operation and latest standards for Wi-Fi, and the essentials of satellite communications.

We'll cut through the jargon to demystify wireless, explaining the fundamentals of cellular and mobility, the buzzwords, the network, technologies and generations, the underlying ideas, and how it all works together... in plain English.

Course Outline

1. Introduction
Course introduction and overview. Basic radio principles, analog and digital over radio.

2. Mobile Network Components, Jargon and Basic Operation
Handset, base station, airlink, handoffs, connection to wireline systems

3. Cellular Principles
The requirements of coverage, capacity and mobility: cellular for coverage, spectrum sharing for capacity, and handoffs for mobility.

4. PSTN Calls Using the Native Phone App: "Voice Minutes"
Components and operation involved in a phone call: microphone, codec, RF modem, antenna, backhaul and connection to other carriers at the Toll Center building

5. Mobile Internet: "Data Plan"
Mobile Internet via a smartphone; using the RF modem and antenna as a tethered modem, mobile Wi-Fi hotspot.

6. Spectrum-Sharing Technologies: FDMA, TDMA, CDMA, OFDM
Sorting out the generations and standards

7. 4G LTE: Mobile Broadband
Subcarriers, how LTE implements modems on subcarriers, and OFDMA for dynamic capacity sharing.

8. 5G New Radio: Enhanced Mobile Broadband, IoT Communications
New spectrum and use cases: more b/s at conventional frequencies, ultra-broadband in millimeter-wave bands, and low bit rates for IoT devices.

9. Wi-Fi: 802.11 Wireless LANs
Wi-Fi components and principles of operation, 802.11 standards, frequency bands and coverage, including Wi-Fi 6 802.11ax, implementing OFDMA with massive performance increase. Completed with WPA-2 and WPA-3 Wi-Fi security.

10. Communication Satellites
Geosynchronous Earth Orbit and Low Earth Orbit, Iridium Next and Starlink.

Prerequisites

None. Course 2201 The PSTN has some relevance, as the mobile networks connect to the wireline Public Switched Telephone Network. Courses 2211 Ethernet, LANs and VLANs, and 2213 IP Networks, Routers and Addresses are relevant to Lesson 9.

Course Objectives: What You Will Learn

The objective of this course is to develop a solid understanding of mobile cellular communications networks and technologies. After taking this course, you will be up to speed on the fundamental principles of cellular radio networks, components and operation, digital radio, spectrum-sharing technologies and the four generations of mobile cellular technology. An additional objective is a basic understanding of WiFi and satellites.

On completion of this course, you will be able to:

- Describe the basic concepts of a mobile communication system, identifying the principal components, the objectives of coverage, capacity and mobility, and the operation including registration and handoffs.
- Explain what “cellular” means and why radio systems are designed as cellular systems.
- Explain how digital cellular can be used for what used to be called “data” (now basically Internet access), using a phone as a tethered modem to connect a computer for Internet access, using a phone as a Wi-Fi hotspot for other computers, or of course surfing the web and using apps directly from a smartphone.
- Explain the principles and describe the operation of the different spectrum-sharing technologies: FDMA, TDMA, CDMA and OFDM.
- Define the term subcarrier, how subcarriers are used, and OFDMA.
- Identify the spectrum 5G will be deployed on and use cases for each.
- Explain the basics of 802.11 wireless LANs, Wi-Fi and hotspots and compare and contrast that to cellular radio.
- Describe the two basic strategies for communication satellites and the pros and cons of each.

Detailed Course Description

We begin with basic concepts and terminology involved in mobile networks, including base stations and transceivers, mobile switches and backhaul, handoffs, cellular radio concepts and digital radio concepts.

You'll understand how a phone call connects from a cell phone to a landline, and the different methods of allowing other devices to use a smartphone's mobile Internet connection.

Without bogging down on details, we'll review spectrum-sharing technologies: FDMA for first generation; 2G GSM/TDMA, 3G CDMA and 4G and 5G OFDM.

We'll take some time to understand how modems represent bits on subcarriers, and how OFDMA is used in 4G and 5G to dynamically assign subcarrier(s) to users.

This is followed with Wi-Fi, or more precisely, 802.11 wireless LANs: the system components, frequency bands, bitrates and coverage. We'll also cover WPA-2 and WPA-3 security.

The course is completed with communications satellites, in Geosynchronous Earth Orbit and Low Earth Orbit, including Iridium Next and Starlink.

Lesson 1. Course Introduction
The first lesson begins the course with an overview of the course and lessons, plus general radio principles.
This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the quality of the course graphics, text and presentation.

Lesson 2. Mobile Network Components, Jargon and Operation
The basic components and operation of a mobile communication network, including handset, airlink, antennas, base station, transceiver, mobile switch, backhaul, registration and handoffs.

Lesson 3. Cellular Principles
In this lesson, we'll begin with the requirements on the communication system: mobility, coverage and capacity, then cover the idea of a cellular radio system, and how it is used to meet the coverage requirement, how frequency-division multiplexing was used to meet the capacity requirement in the first generation of cellular.

Lesson 4. PSTN Calls Using the Phone App: "Voice Minutes"

We'll explore how voice is communicated over the radio access network, and how it connects to the world to make regular telephone calls. In this lesson, we'll understand POPs, Toll Centers and the legacy Tandem Access Trunks used to connect the mobile network to the local phone company, other Local Exchange Carriers like cable TV companies and competing mobile operators, and to Inter-Exchange Carriers.

Lesson 5. Mobile Internet: "Data Plan"

Next, we'll understand how the mobile network connects to the Internet at Internet Exchanges, transit and peering, and how devices can connect to the handset to gain access to its Internet connection, using it as a tethered modem, implementing a Wi-Fi access point in the handset, connecting with Bluetooth; or using the smartphone itself.

Lesson 6. Spectrum-Sharing Technologies: FDMA, TDMA, CDMA, OFDM

Cellphones transmit and receive signals over shared radio bands. To separate users so that they do not interfere with one another, nor hear each other's conversations, service providers use one of four radio band or spectrum sharing methods: Frequency-Division Multiple Access (FDMA), Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA) and Orthogonal Frequency-Division Multiplexing (OFDM).

Lesson 7. 4G LTE: Mobile Broadband

After more than 20 years of incompatible 1G, 2G and 3G systems, 4G was the first world standard for mobile. Since 4G, along with 5G, DSL, Cable modems and Wi-Fi all use OFDM, we'll spend some time understanding OFDM, subcarriers and modulation, and how 4G implements OFDMA to support multiple users.

Lesson 8. 5G New Radio: Enhanced Mobile Broadband, IoT

In the last lesson on mobility, we'll explore the fifth generation, called New Radio in standards committees. You'll learn about the new spectrum for 5G, from the 600 MHz to millimeter-wave bands, and the bit rates to be expected at each. We'll discuss the design goals for 5G, and finish with use cases including low-bandwidth IoT applications and ultra-bandwidth for VR.

Lesson 9. 802.11 Wireless LANs - WiFi

Here, we provide an overview of the 802.11 wireless LAN standards, Wi-Fi and hotspots. We concentrate on understanding the variations of 802.11, the frequency bands they operate in, bit rates to be expected, propagation issues, and Wi-Fi 6, which is 802.11ac, the first to implement OFDMA.

Since 802.11 is wireless LANs, there are a number of associated topics: LAN frames, also called MAC frames, MAC addresses, LAN switches, IP addresses, routers and network address translation. Those topics are covered in other courses, particularly "Ethernet, LANs and VLANs", "Introduction to Datacom and Networking" and "IP Networks, Routers and Addresses". In this course, we concentrate on radio.

Lesson 10. Communication Satellites

In this last lesson of the course, we will take a quick overview of communication satellites, understanding the basic principles and the advantages and disadvantages of the two main strategies: Geosynchronous Earth Orbit and Low Earth Orbit, with an update on Iridium Next and Elon Musk's Starlink

Course 2212 The OSI Layers and Protocol Stacks

Protocols & Standards • Open Systems • OSI Model • Layers • Protocol Stacks • FedEx Analogy

14 interactive multipart lessons, multiple-choice exam and certificate. Produced 2012.

The OSI Layers and Protocol Stacks begins the discussion of IP-based telecom in the Certified Telecommunications Network Specialist (CTNS) certification package. It is the first course in the Certified IP Telecom Network Specialist (CIPTS) package.

This course establishes a framework for all of the subsequent discussions: the OSI 7-Layer Reference Model, which identifies and divides the functions to be performed into groups called *layers*. This framework is required to sort out the many functions that need to be performed, and to be able to discuss separate issues separately.

You'll learn what a layer is, the purpose of each layer, see examples of protocols used to implement each layer, and learn how a protocol stack really works with the famous "FedEx Analogy" presented as an embedded video by our top instructor, Eric Coll.

We'll cut through the jargon to demystify layers, explaining jargon and buzzwords, and most importantly, the underlying ideas, and how it all works together… in plain English.

Course Outline

1. Introduction
Course introduction and overview.

2. Open Systems
Open systems vs. proprietary systems.

3. Protocols and Standards
The difference between a protocol and a standard.

4. ISO OSI 7-Layer Reference Model
Top-level overview and introduction to Layers

5. The Physical Layer
Fiber, Twisted Pair, Cable and Wireless

6. Data Link Layer
LANs and MAC Addresses

7. Network Layer
IP, MPLS, Packets and Routers

8. Transport Layer
Reliability, Connections, Ports and Sockets

9. Session Layer
SIP, POP and HTTP

10. Presentation Layer
ASCII, MIME, Compression, Encryption, Codecs

11. Application Layer
SMTP, HTML and English

12. Protocol Stacks
The FedEx Analogy

13. Protocol Headers
Babushka Dolls

14. Standards Organizations

Prerequisites

None. This is the best course to begin learning about IP and MPLS.

Course Objectives: What You Will Learn

This course can be taken by both those who need simply an overview and introduction to the idea of layers and the OSI model, and by those embarking on a certification and/or planning to take further courses.

If you're in the first group, the objective is not to become an instant expert, but rather to become familiar with the structure that is used to be able to discuss separate issues separately, what a layer is, the basic functions of each layer, what a protocol stack is and how it works, and where things you've heard of before like Ethernet, IP and TCP fit into the picture… to demystify the jargon and buzzwords, to eliminate frustration and increase your confidence and effectiveness.

If you're in the second group, and your objective is to put in place a structure for subsequent courses, following is a list of concrete objectives. On completion of this course, you will be able to explain:

- The concept of an open system and its advantages
- What a protocol is and what a standard is
- The OSI Model and its purpose
- What a Layer is
- The seven layers of the OSI model
- The name of each layer
- The functions each layer is responsible for
- Examples of actual protocols for each layer
- What a protocol stack is and how it operates
- Examples of standards organizations that publish protocols

Detailed Course Description

There are so many functions that need to be performed to be able to interwork different systems, a structure is required to be able to categorize and separate functions, so that it is possible to discuss separate issues separately and not mix things up. The method most commonly used to enable discussion of separate issues separately is the ISO OSI 7-layer Reference Model.

We'll start our discussion with some definitions, then an overview of the OSI model, introducing the ideas of layers, layered architectures and protocol stacks. Then we'll go through the layers individually and give examples of protocols like IP, TCP, LANs and DSL to see where they fit into the stack. We'll finish off understanding how a protocol stack actually works in operation, and conclude the course with a review of different active standards organizations.

Lesson 1. Course Introduction
The first lesson begins the course with a preview of the different functions that must be performed with a multimedia slideshow to illustrate the functions, then an overview of the course and lessons.

This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the quality of the course graphics, text and presentation.

Lesson 2. Open Systems
In this lesson, we'll understand what is meant by an "open" system, and its advantages over proprietary systems and previous methods of interoperation.

Lesson 3. Protocols and Standards
Here, we'll sort out what is meant by the term "protocol", and how that relates to the concept of a standard. We will also start considering how many functions have to be performed to interoperate systems, and how these functions might be organized.

Lesson 4. The ISO OSI 7-Layer Reference Model
The ISO OSI 7-Layer Reference Model is the model most commonly used to define the structure of the "set of structured protocols" introduced in the previous lesson. We'll understand the reference model and how it operates, then introduce the layers in the OSI model, the name of each layer and the functions of each layer. In subsequent lessons, we'll go over the story again, more slowly, one layer at a time.

Lesson 5. The Physical Layer: Fiber, Twisted Pair, Cable and Wireless
Layer 1 is moving bits over Fiber, Twisted Pair, Cable and Wireless

Lesson 6. The Data Link Layer: LANs and MAC Addresses
Next is Layer 2, the Data Link Layer, responsible for managing aspects of communications between two stations on the same circuit. We'll cover frames, LANs and MAC addresses.

Lesson 7. The Network Layer: IP, MPLS, Packets and Routers
Here, we'll see that the definition of a network is connecting many data links together with network equipment, usually with redundant paths for availability and performance reasons. This implies the requirement to make route decisions. We'll see that the two basic kinds of networks are circuit-switched, i.e. the traditional telephone network, and packet-switched, networks using routers to forward packets from one link to another.

Lesson 8. The Transport Layer, Ports and Sockets
In this lesson, we'll cover Layer 4: the Transport Layer. We will see that there are two main functions: reliability of communications between the two end-point devices, and narrowing down the communications to particular software applications running on the devices. TCP and UDP are Layer 4 protocols in the OSI Model.

Lesson 9. The Session Layer: SIP, POP and HTTP
Layers 5, 6 and 7 are referred to as the “upper layers”. In this lesson, we will understand the functions associated with Layer 5: the session layer, responsible for initiating, maintaining and terminating sessions between software applications on different machines connected by a transport service. We will see that the usual implementation follows a client-server scenario, with the client logging on the server with a user name and password and having permissions after being authenticated. In other cases, the session establishment is less sophisticated, for example, no authentication and a session that lasts for the transfer of one web page; and in yet other cases is more sophisticated, involving the communication of the endpoints’ IP addresses to each other so they can subsequently communicate directly as is the case with SIP.

Lesson 10. The Presentation Layer: ASCII, MIME, Compression, Encryption, Codecs
Layer 6 is the Presentation Layer, a very important discussion, as this is the coding step, where messages are coded into 1s and 0s for eventual communication. ASCII, MIME, compression, encryption, and codecs all fit into this layer.

Lesson 11. The Application Layer: SMTP, HTML and English
In this lesson, we’ll examine the uppermost layer of the OSI model, Layer 7, the application layer. We will see that the application layer specifies the message to be transmitted to another system. It defines the format, vocabulary and syntax of messages. The same software that implements the application layer usually also implements a Human-Machine Interface… since in many instances, a human generates the content of the message.

Lesson 12. Protocol Stacks: The FedEx Analogy
In this lesson, we’ll employ an analogy of business-to-business communications using FedEx to illustrate how a protocol stack works, and better understand the OSI layers from a procedural point of view: how information travels down through the protocol stack on the left, through the network equipment in the center, and back up the protocol stack on the right. This lesson features video of our top instructor, Eric Coll, explaining the FedEx analogy to you via the camera on the left side of the screen, plus a graphical illustration on the right. Enjoy!

Lesson 13. Protocol Headers and Babushka Dolls
We’ll understand how a protocol stack works from a bits point of view: how one layer passes a block of 1s and 0s called a Protocol Data Unit to a lower layer, which performs its functions and adds control information in a header to create a bigger PDU, which is then passed down to the next lower layer. The result is like Russian Babushka dolls: a small doll inside a bigger one, inside a bigger one, inside a bigger one… and in our case, repeating seven times.

Lesson 14. Standards Organizations
The last lesson in this course is Standards Organizations, a brief overview of organizations that publish what they hope will become standard protocols for communications.

Course 2211 Ethernet, LANs and VLANs

MAC Addresses • 802.3 and Ethernet • Broadcast Domains • LAN Cables • Switches • VLANs

8 interactive multipart lessons, multiple-choice exam and certificate. Produced 2012.

Ethernet LANs are the standard method of implementing Layer 2 of the OSI Model, data links for communications between two machines. Taking this course, you'll gain a solid understanding of LANs: Ethernet and its bus topology, CSMA-CD access control, broadcast domains and MAC addresses; MAC frames, the IEEE 802 standards, evolution of Ethernet from 10BASE-T to Gig-E, hubs and switches, LAN cables, the TIA-568 cable categories, basic cabling design; what "bridging" means, how a LAN switch works, VLANs and finishing with a preview of the next course: using routers to move frames between broadcast domains.

We'll cut through the jargon to demystify Ethernet, MAC addresses, LANs and VLANs, explaining the jargon and buzzwords, the underlying ideas, and how it all works together… in plain English.

Course Outline

1. Introduction
Course introduction and overview

2. Bus Topology
Broadcast domains, MAC addresses, CSMA-CD access control

3. Ethernet and 802.3
IEEE 802 standards, 802.2 and 802.3, MAC frames

4. Evolution of Ethernet
10BASE-2, 10BASE-T → Gigabit Ethernet and Optical Ethernet

5. LAN Cabling and TIA-568 Categories
Category 5, 5e and 6 cables, basic cabling design

6. Bridging
Connecting broadcast domains, bridged services

7. LAN Switches
Layer 2 switches, MAC tables

8. VLANs
Broadcast domains defined in software

Prerequisites

None. Course 2212 The OSI Layers and Protocol Stacks is useful to understand where LANs fit into the overall picture and how LANs and VLANs relate to routers and IP.

Course Objectives: What You Will Learn

The objective of taking this course is to become familiar with the standard technology used to implement Layer 2 in IP-based packet networks. After taking this course, you will be up to speed on MAC addresses and MAC frames, broadcast domains, LAN cables and LAN switches, VLANs and Optical Ethernet.

In particular, on completion of this course, you will be able to explain:

- The original bus design for a LAN, called Ethernet
- How the bus created a need for an access control protocol, and the CSMA-CD protocol that was implemented for Ethernet
- How the bus implements a broadcast domain, and the MAC addressing scheme that was implemented to identify stations
- The standardization of Ethernet with the IEEE 802 series of standards, understanding 802.2 and 802.3
- Evolution of Ethernet from 10 Mb/s on coaxial cables to Gigabit Ethernet on copper and fiber, and the codes like 10BASE-T used to refer to the various versions
- LAN cables and the TIA-568 cable categories
- How LANs are connected together: bridges and LAN switches, also called “Layer 2” switches, and
- How VLAN technology is used to separate devices on LANs into different broadcast domains.

Detailed Course Description

LANs are the standard method of implementing data links for communications between machines. This began as in-building communications using bus cables, and has evolved to switches and twisted pair cables inside the building, and Optical Ethernet equipment and fiber outside the building.

We’ll begin the course with the original fundamental ideas of a bus topology, contention-based access control, broadcast domains, MAC addresses and MAC frames. Then we’ll review the IEEE 802 standards and evolution of Ethernet from 10BASE-T to Gig-E, LAN cables, the TIA-568 cable categories, basic cabling design; what "bridging" means, how a LAN switch works, and finishing with VLANs and a preview of the next course: using routers to move frames between broadcast domains.

Lesson 1. Course Introduction

The first lesson begins the course with an overview of the course and lessons.

This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the quality of the course graphics, text and presentation.

Lesson 2. Bus Topology

In this lesson, we will understand the fundamental ideas behind LANs: the original bus design for Ethernet, the CSMA-CD access control protocol, the concept of a broadcast domain and the need for MAC addresses.

Lesson 3. 802.3 and Ethernet
Next, we'll understand how the original Ethernet technology was transformed into the set of "802" standards from the IEEE, including changes from coaxial cable to twisted pair cables and the need for hubs.

Lesson 4. Evolution of Ethernet
The purpose of this lesson is to understand the evolution of Ethernet from the initial bus-cable design, which is now called 10BASE-5, through to variations of Gigabit Ethernet, including 1000BASE-T.

Lesson 5. LAN Cabling
In this lesson, we'll explore the TIA standards for LAN cables, and understand which category of cable is applicable for which line speed of LAN.

Lesson 6. Repeaters, Bridges and Loading Curves
Here, we will relatively quickly cover the older idea of using bridges to connect LAN cable segments together. This allows us to discuss overloading problems, and paves the way for the next lessons, LAN switches and routers, and the advanced idea of VLANs.

Lesson 7. Ethernet Switches
In this lesson, we'll understand the technology that has replaced bus cables, hubs, repeaters and bridges: Ethernet switches, also known as LAN switches and Layer 2 switches. We'll understand what an Ethernet switch does, why it is faster than a bridge, how it solves the overloading failure mechanism, but how it still connects all of the stations in a single broadcast domain from a security point of view.

Lesson 8. VLANs
In the last lesson, we'll cover Virtual Local Area Networks or VLANs, a software trick allowing broadcast domains to be defined in software rather than just in hardware. This is used to separate computers into different broadcast domains so that they can not communicate directly for security reasons.

We'll finish the lesson with a peek at the next course: how the broadcast domains are connected via a router, which uses IP packets, and implements a point of control to allow or deny communications between broadcast domains.

Course 2213 IP Networks, Routers and Addresses

IP Packets • Networks • Routers • Static, Dynamic, Public, Private Addresses • NAT • IPv6

11 interactive multipart lessons, multiple-choice exam and certificate. Produced 2012.

IP Networks, Routers and Addresses is a comprehensive course on Layer 3 of the OSI Model, concentrating on IP addresses, routers and packets.

You'll gain a solid understanding of the key principles of packet networks: bandwidth on demand, packet forwarding and packet filtering, how routers work, all of the different types of IP version 4 addresses: static and dynamic, public and private, network address translation plus IP version 6.

Based on Teracom's famous Course 101, tuned and refined over the course of 20 years of instructor-led training, we'll cut through the jargon to clearly explain IP and routers, packets and addresses, the underlying ideas, and how it all works together… in plain English.

Course Outline

1. Introduction
Course introduction and overview

2. Review: Channelized Time-Division Multiplexing (TDM)
Traditional TDM – and why it is inefficient

3. Statistical Time-Division Multiplexing: Bandwidth-on-Demand
Overbooking and opportunistic capacity

4. Private Network: Bandwidth on Demand + Routing
The simplest framework for understanding routers and bandwidth on demand

5. Routers
Routers and routing tables. Packet forwarding and packet filtering. Customer Edge.

6. IPv4 Addresses
Address classes and dotted-decimal notation.

7. DHCP
Dynamic addresses and static addresses – and how both are assigned using DHCP

8. Public and Private IPv4 Addresses
How to obtain public addresses, and why private addresses are used in many cases

9. Network Address Translation
How a NAT glues private IPv4 addressing used in-building to public addressing used on the Internet

10. IPv6 Overview
Introduction to IPv6, what's new, the improvements on IPv4 and the IPv6 packet format.

11. IPv6 Address Allocations and Assignment
Types of IPv6 addresses, registries and allocations to ISPs. How subnets are assigned to end-users.

Prerequisites

None. Course 2212 The OSI Layers and Protocol Stacks is useful to understand where IP and packets fit into the overall picture. Course 2211 Ethernet, LANs and VLANs complements this course, as IP packets are usually carried on Ethernet.

Course Objectives: What You Will Learn

The objective of this course is to develop a solid understanding of IP. After taking this course, you will be up to speed on the fundamental principles of packet networks: bandwidth on demand, also known as overbooking or oversubscription, and packet forwarding. You will know the IP packet format and how IP addresses are allocated, assigned and displayed. You will know the difference between static and dynamic addresses, public and private addresses and how Network Address Translation works. An additional objective is to become familiar with the basics of IPv6.

In particular, on completion of this course, you will be able to explain:

- The concept of statistical multiplexing, also known as oversubscription, overbooking and bandwidth on demand, why and how it can be implemented and its benefits.
- What a private network is
- What a router is and how it implements the network by connecting data links
- How routers move packets between broadcast domains, including VLANs
- How routers also act as a point of control for traffic, called packet filtering
- The basic structure and contents of a routing table
- The Customer Edge
- IPv4 address blocks: Class A, Class B and Class C, and dotted-decimal notation
- Static addresses and dynamic addresses, and how and why DHCP is used to assign both
- Public addresses and private addresses, how, why and where each is used
- Network Address Translation for interfacing domains where public addresses are used with those where private addresses are used
- The improvements and changes between IPv4 and IPv6, and
- The types of IPv6 addresses, how IPv6 addresses are allocated to ISPs then assigned to users, and how each residence gets 18 billion billion IPv6 addresses.

Detailed Course Description

Packet networks embody two main ideas: bandwidth on demand and packet switching. First, we'll recap channelized TDM and its limitations, then understand statistical TDM or bandwidth on demand. Next, we'll understand how routers implement the network with packet-switching, that is, relaying packets from one circuit to another, and how routers are a point of control for network security. We'll introduce the term Customer Edge (CE), and understand the basic structure and content of a routing table.

Then we'll cover the many aspects of IP addressing – needed to be able to do the packet switching: IPv4 address classes, dotted decimal notation, static vs. dynamic addresses, DHCP, public vs. private addresses, Network Address Translation, and finish with an overview of IPv6 overview and IPv6 address allocation and assignment.

Lesson 1. Course Introduction

The first lesson begins the course with an overview of the course and lessons.

This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the quality of the course graphics, text and presentation.

Lesson 2. Review: Channelized Time-Division Multiplexing (TDM)

We'll review the idea of channelized Time-Division Multiplexing (TDM), what channels are, and how they can be used to aggregate traffic onto a high-speed circuit. Then we'll raise some questions: is that an efficient way to connect devices that produce traffic in bursts, which means devices that are normally doing nothing? And what about the problem of a single point of failure for all the aggregated traffic? Subsequent lessons explore the answers to those questions.

Lesson 3. Statistical Time-Division Multiplexing: Bandwidth-on-Demand

In this lesson, we'll understand how circuits that move bits constantly can be used efficiently when the user's traffic profile is: "idle most of the time, interspersed with bursts of data every once in a while." The answer is overbooking. This is also called statistical multiplexing and bandwidth-on-demand, and is a key part of a packet network: the internal circuits are heavily overbooked, to give users the highest speed at the lowest cost. It is necessary to know the users' historical demand statistics – also called their traffic profile – to know how much to overbook, hence the term statistical multiplexing.

Lesson 4. Private Network: Bandwidth on Demand + Routing

The purpose of this lesson is to expand the discussion of the previous lesson to include multiple circuits. The result is called a private network, and is the simplest framework for understanding routers, routing, network addresses and bandwidth-on-demand.

Lesson 5. Routers

In this lesson, we'll take a closer look at a router, more precisely identifying the functions a router performs to implement a packet network, and understand how a router routes by examining the basic structure and content of a routing table. We'll also understand how the router can act as a point of control, denying communications based on criteria including network address and port number, why this is implemented and its limitations. The term Customer Edge (CE) is defined in this lesson.

Lesson 6. IPv4 Addresses
Here, we'll understand IPv4 addresses, address classes and the dotted-decimal notation used to represent them.

Lesson 7. DHCP
In this lesson, we'll cover DHCP: the Dynamic Host Configuration Protocol, and understand the mechanism by which a machine is assigned an IP address. We'll also understand how the "dynamic" host configuration protocol can be used to assign static addresses to machines and the advantages of this method.

Lesson 8. Public and Private IPv4 Addresses
The purpose of this lesson is to define the terms "public" and "private" IP address, review how IP addresses are assigned and the costs for those addresses, then cover the ranges of IPv4 addresses that are used as private addresses, and understand how and why they are used.

Lesson 9. Network Address Translation
In this lesson, we'll explore how private IPv4 addresses used in-building and a public address required for Internet communications can be joined together with a software function called Network Address Translation.

Lesson 10. IPv6 Overview
Completing this course on IP, we'll first review the next generation of IP: IPv6, understand the improvements compared to IPv4 and review the format of the IPv6 packet and its header.

Lesson 11. IPv6 Address Allocations and Assignment
Finally, we examine the structure of the 128-bit IPv6 address, review the different kinds of IP addresses, the organizations that allocate them, and the current plans for how addresses will be assigned to end users… and how every residence gets 18 billion billion IPv6 addresses.

Course 2214 MPLS and Carrier Networks

Carrier Packet Networks • Technologies • MPLS • SLAs • CoS • Integration & Aggregation

15 interactive multipart lessons, multiple-choice exam and certificate. Produced 2012.

MPLS and Carrier Networks is a comprehensive training course designed to build a solid understanding of carrier packet networks and services, the terminology, technologies, configuration, operation and most importantly, the underlying ideas … in plain English.

We'll cut through the buzzwords and marketing to demystify carrier packet networks and services, explaining Service Level Agreements, traffic profiles, virtual circuits, QoS, Class of Service, Differentiated Services, integration, convergence and aggregation, MPLS and other network technologies, and how they relate to TCP/IP without bogging down on details.

You will gain career- and productivity-enhancing knowledge of the structure, components and operation of carrier packet networks and services, how they are implemented, packaged and marketed by carriers and how they are used by government, business… and other carriers.

Course Outline

1. Introduction
   Packet Switching and Bandwidth on Demand concepts. Course overview.
2. Carrier Packet Network Basics
   Customer Edge, Provider Edge, Access and Core
3. Service Level Agreements
   Traffic Profile and Class of Service
4. Virtual Circuits
   Traffic Classes, Virtual Circuits and Virtual Circuit IDs
5. X.25
   Packet Network Protocol Stack & OSI Layers
6. Frame Relay
   Frame Relay vs. Packet Switching, IP, TCP, FRADs
7. TCP/IP over Frame Relay
   Tracing a file download end-end through the equipment and protocols
8. QoS Requirement for Voice over IP
   How packetized voice works and what is needed
9. ATM
   Brief overview: ATM objectives, cells, Service Classes
10. MPLS
    MPLS components, jargon, basic operation
11. TCP/IP over MPLS
    Tracing a file download end-end, MPLS for VPN or VPLS
12. Differentiated Classes of Service using MPLS
    QoS, traffic classification, Diff-Serv: multiple CoS
13. Integration and Convergence using MPLS
    Carrying all traffic on a single network technology

14. Managing Aggregates of Traffic with MPLS Label Stacking
    Carrying virtual circuits on virtual circuits – access and core
15. MPLS Services vs. Internet Service
    Similarities and differences, pros and cons. The Future.

Prerequisites

Courses 2212 OSI Layers, 2211 LANs and 2213 IP are recommended. Those courses, along with this one, are included in both the Certified Telecommunications Network Specialist (CTNS) and the Certified IP Telecom Network Specialist (CIPTS) certification packages.

Course Objectives

This course can be taken by both those who need simply an overview and introduction to carrier packet networks and MPLS, and by those who need to build a solid base and get up to speed on all or most of the listed topics.

If you're in the first group, the objective is not to become an instant expert, but rather to become familiar with the structure, components and operation of carrier packet networks and services, how they are packaged, marketed and used, and to demystify the jargon and buzzwords, to eliminate frustration and increase your confidence and effectiveness.

If you're in the second group, and your objective is to get up to speed on all or most of the listed topics, putting in place a base that project- or job-specific knowledge can be built on, following is a list of concrete objectives. On completion of this course, you will be able to:

- Explain the components and basic structure of a carrier packet network including core, provider edge, access and customer edge,
- List three ways packet services are better than dedicated lines for wide-area networking,
- Define a Service Level Agreement, Class of Service and traffic profile,
- Define a traffic class and explain what a virtual circuit is, and what they are used for,
- Differentiate between a reliable and unreliable Class of Service and what must be done to accommodate the latter, and briefly explain connection-oriented and connectionless communication modes,
- Explain the fundamentals of Frame Relay: how Frame Relay got its name, how IP is carried over Frame Relay, why TCP is also required, and the traffic profiles supported,
- Identify the steps involved in communicating voice in packets, and what transmission characteristics are critical to call quality,
- Briefly describe the characteristics of ATM and the classes of service it was supposed to implement to support telephone calls,
- Show how MPLS is essentially the same thing as X.25, Frame Relay and ATM but with different jargon – and identify that jargon, including defining the meaning and purpose of a label, and identifying where the label is placed in the headers,
- Trace the flow of a message transported by TCP in IP packets over an MPLS

network,

- Identify the benefit of MPLS compared to Frame Relay from the user's point of view,
- Explain what Differentiated Services are, and how MPLS labels can be used to implement Diff-Serv, and an alternative,
- Explain how and why MPLS can be used to achieve service integration,
- Show how MPLS can be used to aggregate traffic,
- Explain what exactly someone means when they say "MPLS service" and explain why "IP service with a service level agreement" would be a more accurate term, and
- Identify two differences between MPLS service and Internet service, and the pros and cons of each.

Detailed Course Description

Lesson 1. Course Introduction

The first lesson recaps the concepts of packet switching and bandwidth on demand, then provides an overview of the topics that will be covered, the course objectives and a description of each lesson. This lesson is available for free on teracomtraining.com and provides both a walkthrough of the course and a sample of the quality of the course graphics, text and presentation.

Lesson 2. Carrier Packet Network Basics

The fundamental concepts of packet switching and bandwidth-on-demand or overbooking, the physical components involved in using a carrier packet network service including Customer Edge, types of access circuits, the Provider Edge and the network core – and why PE equipment is sometimes deployed at the customer premise. This lesson is completed with a roundup of the benefits of packet services over dedicated lines and circuit-switched connections.

Lesson 3. Service Level Agreements: Traffic Profile and Class of Service

How performance is specified, measured, guaranteed and controlled on an overbooked bandwidth-on-demand network – the Service Level Agreement where the network guarantees specified transmission characteristics, sometimes called a Class of Service, on condition that the customer stays within a defined traffic profile … and what happens to out-of-profile traffic.

Lesson 4. Virtual Circuits

The fundamentals of virtual circuits, an essential part of all packet communication networks. We'll cover the concepts of traffic classes, virtual circuits, virtual circuit IDs and the fundamental principles of operation that are common to all technologies, including MPLS, and how virtual circuits are a powerful traffic management tool.

Lesson 5. X.25: Data Packet Service from The Phone Company

Beginning with this lesson, we'll run through the main virtual circuit technologies, starting with X.25. We won't spend any time on details of X.25, as it was replaced with Frame Relay then MPLS, but instead use it to introduce a graphical method of showing how packets travel between routers in frames over physical connections from user to network to user, plus concepts and jargon including connection-oriented vs. connectionless network service and reliable Class of Service vs. unreliable and pave the way for understanding current technologies Frame Relay and MPLS, and the

improvements each brought to the table.

Lesson 6. Frame Relay
How Frame Relay was an improvement, why it's called "Frame Relay" along with other jargon, and why IP and TCP are required in conjunction with Frame Relay service. We'll identify the equipment used for Frame Relay and the traffic profiles it supports.

Lesson 7. TCP/IP over Frame Relay
In this lesson, we'll trace the flow of information from a server to a client across a Frame Relay service, identifying the protocol stacks on the terminals and edge equipment. This will allow understanding how Frame Relay network service from a carrier relates to TCP and IP used by a customer, and the requirements for connecting to a carrier's Frame Relay service.

Lesson 8. QoS Requirement for Voice Over IP
Packet network services were originally designed for datacom. In this lesson, we'll understand how voice is packetized, carried over a packet network, then reconstructed at the far end – and the transmission characteristics necessary for voice quality.

Lesson 9. ATM
ATM was supposed to be The Solution, allowing integration and convergence of all services on a packet network, as it was designed to guarantee the transmission characteristics necessary for voice and video in packets – but it became horribly complicated and expensive and is on the way out, so will simply provide an overview of ATM and its jargon.

Lesson 10. MPLS
IP has emerged as the standard for packets that will carry all traffic. Since IP provides a connectionless network service, additional protocols are required to implement virtual circuits to enable management and prioritization of traffic. The choice for IP is Multi-Protocol Label Switching (MPLS). The concepts are the same as other virtual circuit technologies X.25, Frame Relay and ATM… but the jargon is changed. We'll begin by identifying MPLS components, jargon and basic principles of operation.

Lesson 11. TCP/IP over MPLS
In this lesson, we'll revisit tracing the path of a file download from server to client, this time over an MPLS network. This will reveal a significant advantage of MPLS-based network services compared to Frame Relay in the user-network interface. We'll also discuss the "M" in MPLS, noting how MPLS can be used to carry frames for VPLS in addition to the usual IP packets.

Lesson 12. Differentiated Classes of Service using MPLS
Here, we'll examine how classifying traffic and mapping classes onto virtual circuits can be a Quality of Service (QoS) mechanism to implement multiple Classes of Service on a packet network. This is sometimes referred to as *differentiated services* or *Diff-Serv*, i.e. providing a different Class of Service for each application: VoIP, IPTV, email, web surfing and others.

Lesson 13. Integration and Convergence using MPLS
In this lesson, we'll see how virtual circuits and traffic classification can be used to combine all of the types of communications of a business or organization onto a single access circuit. This idea is sometimes called *convergence*, though *service integration* is a more accurate term. It results in a large cost savings compared to one access circuit for each type of communications.

Lesson 14. Managing Aggregates of Traffic with Label Stacking
Here, we'll understand how MPLS labels can be stacked… virtual circuits carried over other virtual circuits, and how this is implemented to *aggregate* traffic for both routing and prioritization reasons – both on access circuits and in the network core.

Lesson 15. MPLS Services vs. Internet Service
This lesson completes the course with a discussion of terminology used in sales and marketing of MPLS services, and how that translates to reality. We will use a quiz question-and-answer format to understand the difference between Internet service and what sales brochures call "MPLS service"… and what exactly an "MPLS service" is.