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# Fundamentals of VoIP & IP Telecom Networks

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*A three-day vendor-independent training course covering all aspects of Voice over IP and the modern converged broadband IP telecommunications network it runs on.*

Specifically designed for non-engineering professionals, this course will fill in the gaps and get you up to speed on the fundamentals and the technologies involved with Voice over IP and the network it runs on:

- Today's broadband converged IP telecommunications network
- What all of the VoIP jargon and buzzwords mean
- How VoIP works end-to-end; all of the components involved
- What SIP is,
- How an organization saves money moving to softswitches and SIP trunking,
- The OSI Layers
- Ethernet, IP and MPLS
- Who supplies what, and how it all fits together
- Best practices

Get a solid knowledge base to build on... structured, complete knowledge starting with fundamentals, that you can't get on the job, reading articles or from vendors.

Eliminate buzzword frustration, and gain the knowledge to be confident!

This is career-enhancing knowledge that lasts a lifetime, and training that will be repaid many times over in increased accuracy and productivity.

With case studies and exercises, you will learn how a VoIP call is set up and carried end-to-end, how softswitches and SIP trunking works and much more.

***Bonus! TCO Certified VoIP Analyst (CVA) Certification included!***  
*Six online courses & CVA Certification Exam, with unlimited repeats*

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**Register online at [teracomtraining.com](http://teracomtraining.com)  
or call us toll-free: 1-877-412-2700**

**Fundamentals of VoIP & IP Telecom Networks** is a three-day vendor-independent training course covering all aspects of Voice over IP and the broadband, converged IP network it runs on.

### Key Course Features

- Get up to speed on today's broadband, converged IP telecommunications network
- Learn what all of the VoIP jargon and buzzwords mean
- Find out how VoIP actually works end-to-end, and all of the components involved
- Understand SIP and SIP Trunking
- Get a solid base of fundamentals of the IP network
- Who supplies what, and how it all fits together
- Case studies and class exercises to cement your knowledge
- 300-page color printed course workbook with detailed notes
- Bonus TCO Certified VoIP Analyst (CVA) online courses and certification

### Course Outline

#### Part 1: The Big Picture

1. Introduction to Broadband Converged IP Telecommunications
2. Fundamentals of Voice over IP
3. Network Fundamentals
4. The Many Different Implementations of VoIP

#### Part 2: VoIP and SIP

5. Packetized Voice and Sound Quality
6. SIP and Softswitches
7. SIP Trunking & Carrier Connections

#### Part 3: The IP Network

8. Organizing the Discussion: the OSI Layers
9. Ethernet on Copper, Fiber and Wireless
10. IP Networks, Routers and Addresses
11. Carrier Networks and MPLS VPNs vs. SD-WAN

### Learning Exercises

- Class Exercise: Trace a VoIP Call End-to-End from Wi-Fi and Internet to Cellphone, Identifying All Physical Equipment and Connections
- Class Activity: Listen to Sound Clips with Packet Loss, Delay and Jitter
- Case Study: Migrating Five-State Organization to VoIP – SIP Trunking vs. SD-WAN
- Class Exercise: Examine Actual MAC and IP Addresses in Use
- Group Exercise: Group Collaboration Open-Book Final Exam

### Materials Included

300-page high-quality color printed course workbook with copies of graphics plus detailed notes, sure to be a valuable reference for years to come.

VoIP Quality Metrics and Thresholds poster PDF

### Duration, CPE Credits and Tuition Fees

3 days, CPE credits: 20 contact hours

### Certification & Online Courses Included

TCO Certified VoIP Analyst (CVA) Certification Package, Unlimited Plan

Six online courses + CVA exam, with unlimited course & exam repeats included

# Detailed Course Outline

## Part 1: The Big Picture

### 1. Introduction to Broadband Converged IP Telecommunications

We begin with a comprehensive big-picture introduction to today's telecom network: the concepts of convergence and broadband, the different parts of the network, the three key technologies: Ethernet, IP and MPLS, what they are and what each does. You'll learn how a service is implemented end-to-end, and identify today's standard residential, business and wholesale services.

- A. History of Telecommunications
- B. Convergence
- C. Broadband
- D. Today's Telecom Network
- E. Network Core
- F. Ethernet, IP and MPLS
- G. Network Access
- H. Telecommunication Service Implementation
- I. Carrier Interconnect
- J. Residential, Business and Wholesale Services

### 2. Fundamentals of VoIP

Next, we dive into the fundamentals of Voice over IP: the basics of communicating voice in IP packets, demystifying the jargon and buzzwords and explaining in plain English the components of a VoIP telephone system like soft switches and gateways, what each does, along with protocols like SIP.

- A. The Big Picture
- B. VoIP System Components
  - 1. Terminals
  - 2. Voice in IP Packets
  - 3. Softswitches / SIP Servers / Call Managers
  - 4. Media Servers and Unified Messaging
  - 5. Gateways
  - 6. LANs and WANs
- C. Key VoIP Standards
- D. Where This is Headed: Broadband IP Dial Tone

### 3. Network Fundamentals

In this chapter, we'll cover the essential concepts and technologies of IP networks. We'll review basic circuit configurations, and take a first pass understanding how IP packets are communicated in MAC frames, how routers relay packets from one circuit to another, and how MPLS is used for traffic management. These topics are revisited in detail in later chapters.

- A. Unbalanced Configurations: CATV, PON, Wi-Fi, CAN-BUS
- B. Balanced: LANs and Ethernet
- C. Frames and MAC Addresses
- D. Networks
- E. Packets and IP Addresses
- F. IP Packets in MAC Frames
- G. IP Packets
- H. MPLS Labels

#### **4. The Many Different Implementations of VoIP Part 1: VoIP for Individuals**

"Voice over IP" can happen in many different ways. We'll review the many flavors of VoIP, comparing and contrasting the various implementations and architecture choices. Starting with Internet telephony, we will understand computer to computer VoIP over the Internet and different types of Internet - Public telephone network VoIP. We'll cement your knowledge by tracing a VoIP phone call from a laptop in the classroom over Wi-Fi to the Internet, then to a mobile network operator and to a cellphone in the classroom, identifying all the circuits, components, buildings and companies involved in the end-to-end connection.

- A. Internet Telephony: Computer-Computer VoIP over Internet
- B. Internet Telephony Clients
- C. VSPs: Internet to Phone e.g. Skype to Phone
- D. Class Exercise: Trace a Phone Call from Laptop to Cellphone
- E. VSP: Internet VoIP with Adapter and PSTN Phone Number e.g. Vonage
- F. VoIP Becomes the New POTS

#### ***Class Exercise: Trace a VoIP Call End-to-End Internet to Cellphone***

We'll establish a phone call from a VoIP client on a computer in the classroom via Wi-Fi and the Internet to a cellphone in the classroom, and identify where the voice packets travel, from one circuit, device, and company to the next, end-to-end between the two sets of microphones and speakers. This will cement your understanding of VoIP telephone calls, the telecom business and how everything is connected.

#### **5. The Many Different Implementations of VoIP Part 2: VoIP for Organizations**

Next, we'll look at all the ways VoIP is implemented for organizations, including SIP Trunking to replace expensive PBX trunks. We will compare and contrast choices for a VoIP system: getting it from the phone company; buying a call manager / softswitch; renting a Hosted PBX; and cloud solutions. You'll gain the knowledge to confidently differentiate VoIP architectures and discuss pros and cons of options. We'll complete the discussion with practical examples of VoIP in action.

- A. VoIP-Enabled PBX and Migration Options
- B. Premise Softswitch / Call Manager: PBX Replacement
- C. Hosted PBX and Cloud Services: Softswitch as a Service (SaaS)
- D. SIP Trunking
- E. IP Centrex
- F. Phone Powering and PoE
- G. LAN Configuration for VoIP
- H. Public Safety Communications
- I. Star-Trek Personal Communicators for Hospitals
- J. Applications Running on Business VoIP Phones
- K. IP Call Center Application Example

## Part 2: Nuts and Bolts: VoIP and SIP

### 6. Packetized Voice and Sound Quality

In this chapter, you'll learn what exactly packetized voice is, how it happens, and the various standards in use. You'll learn about the factors affecting sound quality, and how packets actually get "lost" in a network. We'll listen to sound clips of impairments, and provide you with a practical checklist of tips and recommendations for ensuring success.

- A. Voice Packetization
- B. Measuring Voice Quality
- C. Factors Affecting Voice Quality
- D. Codecs: G.711, G.729, HD Voice
- E. Network Delay and Jitter
- F. RTP
- G. VoIP Protocol Stack: RTP, UDP, IP, MAC
- H. How Packets Get "Lost"
- I. Packet Loss and Sound Samples – In-Class Demo
- J. Testing and Troubleshooting
- K. First Step: The IP Network
- L. Second Step: The VoIP
- M. Tips for Maximizing Voice Quality

#### ***Class Activity: Sound Clips with Impairments***

Listening to sound clips, you'll hear the effect of different levels of uncorrected delay, jitter and packet loss, and understand how the quality of the reproduced speech at the far end is affected.

**Bonus!** All students receive a large PDF poster explaining VoIP call quality metrics and thresholds.

### 7. SIP and Softswitches

SIP is the open, standard protocol for setting up Voice over IP telephone calls. All VoIP systems that purport to be "compatible" or "standards-based" must implement the Session Initiation Protocol. SIP defines the procedure and messages to set up a phone call – or any other kind of communication. In this chapter, you'll learn what exactly setting up a VoIP telephone call entails, understand what SIP is, how it works, demystify jargon like proxy server, registration and location server, understand how SIP fits in with softswitches and call managers, and trace the establishment of an IP phone call step by step. At the end of this, you'll understand how VoIP phone calls are set up – maybe worth attending the course all by itself!

- A. What SIP is and What it Can Do
- B. Relationship to Other Protocols
- C. SIP URIs: "Telephone Numbers"
- D. Registration and Location
- E. Outbound Proxy
- F. Finding the Far End
- G. The SIP Trapezoid
- H. SIP Message Example
- I. How SIP Relates to Softswitches and Call Managers
- J. Relating Phone Numbers to SIP URIs

## 8. SIP Trunking and Carrier Connections

We round out the Voice over IP part of the course with connections to carriers, beginning with Class of Service (CoS) performance guarantees and ending with transmission choices: SIP trunking, MPLS VPN and SD-WAN. We'll cover SIP trunking to replace PBX trunks for business phone systems; connecting with gateways and Megaco; and understand how cellular, cable, internet and incumbent carriers connect for PSTN VoIP phone calls.

- A. Connecting with Gateways
- B. Carrier Class of Service (CoS)
- C. SIP Trunking Service
- D. VoIP at Carriers: Session Border Controllers
- E. PSTN VoIP Interconnection at the Toll Center
- F. PSTN Tandem Access Trunk Interconnection at the Toll Center
- G. Comparing Transmission Choices: SIP Trunking, MPLS VPN and SD-WAN

### ***Case Study: Migrating Five-State Organization to VoIP - SIP Trunking vs. SD-WAN***

To cement your understanding of VoIP phone systems and carrier services, and even gain valuable insight into your own situation, we'll examine a multi-state organization's PBX replacement strategy, and the question of internal communications by PBX trunk, by SIP trunking, or by SD-WAN.

## Part 3: The IP Network

### 9. The OSI Layers and Protocol Stacks

The last day is devoted to understanding the modern converged IP-based telecom network. To get started, we'll organize the discussion using the OSI 7-Layer Reference Model, explaining what a layer is, and what the layers are, and giving examples of protocols like TCP and IP and how they work together in a protocol stack.

- A. Protocols and Standards
- B. ISO OSI Reference Model
- C. OSI 7-Layer Model
- D. Physical Layer: Ethernet, Fiber, DSL, cable, wireless
- E. Data Link Layer: 802 MAC
- F. Network Layer: IP and MPLS
- G. Transport Layer: TCP and UDP
- H. Session Layer: POP, SIP, HTTP
- I. Presentation Layer: ASCII, Encryption, Codecs
- J. Application Layer: SMTP, HTML, English ...
- K. Protocol Stack in Operation: Babushka Dolls
- L. Standards Organizations

### 10. Ethernet on Copper, Fiber and Wireless

Ethernet is used in all parts of the network for point-to-point links between devices, implementing Layers 1 and 2 of the OSI model together. In this chapter, we'll review the basic principles of Ethernet and LANs, how it was formalized in the 802 series of standards, the concepts of MAC addresses, MAC frames and broadcast domains. You'll understand how LAN switches, also called Layer 2 switches, connect devices, and how VLANs separate devices as a basic network security function. The chapter finishes with Ethernet on fiber, called Optical Ethernet, and Ethernet over radio, called Wi-Fi.

- A. MAC Addresses, MAC Frames and Broadcast Domains
- B. Ethernet and 802 standards
- C. LAN Cables

- D. Layer 2 Switches
- E. VLANs
- F. Optical Ethernet
- G. Wireless Ethernet (Wi-Fi)

## **11. IP Networks, Routers and Addresses**

This chapter is devoted to IP, used to implement Layer 3. We begin with IP addressing: IPv4 address classes, subnets, DHCP, static and dynamic addresses, public addresses, private addresses and NAT. We use the simplest IP network to explore how routers implement the network by relaying packets from link to link, and also act as a point of control to deny communications based on IP address and/or port number. We'll complete the chapter with IPv6 addressing.

- A. IPv4 Address Classes
- B. Subnets: Prefix and Subnet Mask
- C. DHCP, Static and Dynamic Addresses
- D. Assigning Subnets to Broadcast Domains
- E. IP Network: Routers and Routing Tables
- F. Routers and Customer Edge (CE)
- G. Public and Private IPv4 Addresses
- H. Network Address Translation (NAT)
- I. IPv6
- J. IPv6 Address Allocation and Address Types

### ***Class Exercise: IP and MAC Addresses***

Using the Windows interface, we'll determine the current MAC and IP Addresses of a classroom computer, and the private and public IP addresses of the Edge Router and NAT it's connected to.

This will help visualize what IP addresses are, and covers two of the questions on the Final Exam.

## **12. Carrier Networks and MPLS VPNs vs. SD-WAN**

IP packets are used to carry everything, including phone calls and the Super Bowl. But IP in itself does not include any way to prioritize or manage traffic to guarantee call quality or picture quality. In the core of a carrier's network, MPLS is used to implement those functions. In this chapter, we'll complete your knowledge with the basics of carrier networks and the important concept of a Service Level Agreement. Then you'll gain a practical understanding of how MPLS works and how it is used by carriers to implement MPLS VPNs, different Classes of Service, service integration and traffic aggregation; and contrast that to a cheaper solution: Internet VPNs and SD-WAN.

- A. Carrier Packet Network Basics
- B. Service Level Agreements and Class of Service (CoS)
- C. Provider Equipment at the Customer Premise
- D. Virtual Circuit Technologies
- E. MPLS
- F. MPLS VPNs for Business Customers
- G. MPLS for Service Integration
- H. MPLS and Diff-Serv to Support Classes of Service
- I. MPLS for Traffic Aggregation
- J. Internet VPNs
- K. SD-WAN
- L. Country-Spoofing VPN Service
- M. Anonymizer VPN Service

## Our Goal

Our goal is to bust the buzzwords, demystify jargon, understand technologies and mainstream solutions and - most importantly - the ideas underlying all of this, and how it all works together... knowledge you can't get on the job, talking to vendors or reading trade magazines.

## How You Will Benefit

You'll gain a long-lasting, solid base of unbiased career-enhancing knowledge you can build on, an investment sure to be repaid many times over, increasing your confidence and productivity and eliminating jargon- and buzzword-related frustration.

Plus, you will receive a high-quality 300-page workbook – a valuable reference packed with detailed notes, diagrams and practical explanations, as well as a course completion certificate attesting to your IP telecom knowledge skills.

You can get TCO Certified VoIP Analyst (CVA) Certification by writing the optional CVA exams after the class.

## Don't Miss This Opportunity!

If you've read this far, you know by now that this is the training you've been looking for to fill the gaps and get on top of VoIP and IP Telecom. Coverage of all major topics, high-quality course materials, TCO CVA certification and certificate suitable for framing, bonus poster and value pricing... don't miss this opportunity. Invest in yourself and your career and [register](#) for this course now.

## How to Register

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- Register by phone at 1-877-412-2700

Once you register online or call us, we'll send your registration package by email, including a confirmation letter for you to sign and fax back to complete your registration. There is no obligation until you return the signed confirmation letter and you can cancel anytime up to two weeks before the course with no penalty.

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