
Fundamentals of VoIP & IP Telecom Networks

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

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

- What all of the VoIP jargon and buzzwords mean,
- How VoIP works end-to-end; all of the components involved
- Fundamentals of the network VoIP runs on
- Who supplies what, and how it all fits together
- Best practices, tips and tricks for managing deployment and migration.

Get a solid knowledge base to build on... structured, complete knowledge you can't get on the job, reading articles or talking to 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 an organization saves money moving to softswitches and SIP trunking, project management, best practices and more.

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

**Register online at teracomtraining.com
or call us toll-free: 1-877-412-2700**

Course Facts

Teaching Modules & Course Book Chapters

PART 1: THE BIG PICTURE

1. Fundamentals of VoIP
2. Fundamentals of Telecom
3. Fundamentals of Datacom
4. The Many Different Implementations of VoIP

PART 2: VOIP AND SIP NUTS AND BOLTS

5. Voice Packetization and Voice Quality
6. SIP and Softswitches
7. SIP Trunking & Carrier Connections
8. Testing and Troubleshooting VoIP

PART 3: THE NETWORK

9. Organizing the Discussion: the OSI Layers
10. Ethernet on Copper, Fiber and Wireless
11. IP Addresses and Routers
12. TCP, UDP and Ports
13. IP Network Quality: CoS, QoS, SLAs and MPLS

PART 4: PROJECT MANAGEMENT

14. VoIP Migration Project: Template with Steps, Tips and Tricks

Learning Exercises

Class Exercise: Trace a VoIP Call End-to-End Across Different Networks

Class Activity: Listen to Sound Clips with Packet Loss, Delay and Jitter

Group Exercise: Case Study – Saving Money Migrating Five-State Company to VoIP

Class Exercise: IP and MAC Addresses

Group Exercise: Group Collaboration Open-Book Final Exam

Materials Included

Printed 300-page course workbook with detailed notes, sure to be a valuable reference
VoIP Quality Metrics and Thresholds poster

Duration, CPE Credits and Tuition Fees

3 days, CPE credits: 20 contact hours

Tuition \$1495

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 By Chapter

PART 1: THE BIG PICTURE

1. FUNDAMENTALS OF VOIP

We will start with 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. Why VoIP? Saving Money Via Convergence
- B. VoIP System Components
 - 1. VoIP Phones
 - 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

2. FUNDAMENTALS OF TELECOM

As one of the main uses of VoIP is to make telephone calls, having a solid base in the fundamentals of telecom and the telephone network is essential. You will fill in gaps and learn how the telephone network is structured, who does what, how it's done, and how connections are made. We'll demystify loops and trunks, COs and wire centers, analog, the voiceband, digital, DS0 channels vs. packets, switched access and toll centers, and understand how phone companies, cable companies, wireless carriers and internet VoIP carriers connect.

- A. The Public Telephone Network
- B. Loops, trunks and circuit switching
- C. Analog, The Voiceband and POTS
- D. Line card: in CO, Remote, OPI, CPE, then gone
- E. Voice Digitization: 64 kb/s and DS0s
- F. Voice in Packets vs. Voice in Channels
- G. How and Where Carriers Connect VoIP
- H. Toll Centers and POPs
- I. Access, Switching, Transmission
- J. Connecting Ma Bell, Cellular, Cable and Internet VoIP Carriers

3. FUNDAMENTALS OF DATACOM

In this module, you will learn the basics of data packet networks – now used to carry VoIP phone calls along with Internet traffic, video, business data and everything else. We'll start with circuits, LANs and WANs, then understand the fundamental ideas of how routers relay packets from one circuit to another to reach the far end, and how this is accomplished with addresses and packets carried in frames.

- A. Circuits, LANs and WANs
- B. Frames and MAC Addresses
- C. Packets and IP Addresses
- D. How Routers Implement Networks

4. THE MANY DIFFERENT IMPLEMENTATIONS OF VOIP

“Voice over IP” can happen in many different ways. One by one, we’ll review the many flavors of VoIP, comparing and contrasting the various implementations and architecture choices. Starting with Internet telephony, we will then understand VoIP at the telephone company, how VoIP connects to older systems, and new services like SIP Trunking. 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.

- A. Internet Computer-Computer VoIP, e.g. Skype
- B. VSP: Internet to Phone, e.g. Google Hangouts dialer
- C. VSP: Phone to Phone over Internet, e.g. Vonage
- D. VoIP Becomes The New POTS
- E. VoIP at Carriers
- F. Session Border Controllers
- G. VoIP for Businesses and Organizations
- H. VoIP-Enabled PBX, Migration Options
- I. PBX Replacement with Softswitch / Call Manager
- J. SIP Trunking Replacing PBX Trunks
- K. Hosted PBX
- L. Cloud Services and Softswitch as a Service (SaaS)
- M. IP Centrex
- N. Asterisk and Open-Source Softswitch Software
- O. Phone Powering and Power over Ethernet (PoE)

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 WiFi 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.

PART 2: VOIP AND SIP NUTS AND BOLTS

5. PACKETIZED VOICE AND SOUND QUALITY

In this module, 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 & RTP
- B. UDP and Ports
- C. Protocol Stack: RTP, UDP, IP, MAC
- D. Measuring Voice Quality
- E. Factors Affecting Voice Quality
- F. Codecs: G.711, G.729, HD Voice
- G. Network Delay and Jitter
- H. How Packets Get "Lost"

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.

6. 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. Softswitch vs. PBX or CO Switch
- B. What SIP is and What it Can Do
- C. Relationship to Other Protocols
- D. SIP URIs: "Telephone Numbers"
- E. Registration and Location
- F. Outbound Proxy
- G. Finding the Far End
- H. The SIP Trapezoid
- I. SIP Message Example
- J. Useful Call Disposition Rules Enabled by SIP
- K. Similarities and Differences: VoIP vs. Web Browsing
- L. SIPS: Transport-Layer Security
- M. How SIP Relates to Softswitches and Call Managers
- N. Google Voice: Cloud SIP Services for Individuals

7. SIP TRUNKING AND CARRIER CONNECTIONS

This chapter is all about connecting an in-building business VoIP phone system to the world. First, we'll understand how connections used to be implemented with PBX trunks and ISDN PRI service. Then we'll see how a gateway connects a modern VoIP system onto PBX trunks, and most importantly, how SIP Trunking replaces PBX trunks with a lower-cost and more flexible solution.

Many big organizations have an existing data network, implemented as a VPN by a carrier. We'll look at the advantages and disadvantages of using the "data" VPN, or the Internet, compared to SIP Trunking, and finish off with a practical checklist of features and technologies to require when choosing a carrier.

- A. Installed Base: PBX Trunks & PRI Service
- B. DS0 Interconnect with the Telephone Network
- C. Gateways: PBX Trunks + PRI ↔ IP Packets + SIP
- D. Megaco (H.248/RFC2885) and MGCP
- E. SIP Trunking
- F. Advantages of SIP Trunking over PBX Trunks
- G. VoIP over "Data" VPNs
- H. VoIP over Internet VPNs
- I. Saving Money with Integrated Access
- J. Fallback to PSTN?
- K. Redundancy and Disaster Recovery
- L. Tips for Selecting a VoIP Carrier

Group Exercise: Case Study – Saving Money Migrating Five-State Company to VoIP

To cement your understanding of VoIP phone systems and carrier services, and even gain valuable insight into your own situation, you'll work in a group to come up with the best solution for a company with 5,000 people in five states to migrate from PBX trunks to VoIP. The winners will be the ones who save the most money. Bonus points for saving money and providing useful new features!

8. TESTING AND TROUBLESHOOTING VOIP

We'll round out the discussion of VoIP systems identifying what could go wrong, and how trouble is identified and resolved. Without getting bogged down on technical details, you will learn the main areas where things go wrong, what the trouble symptoms are, and how to go about fixing the problem.

- A. What Could Go Wrong?
- B. Phone Issues
 - 1. Phone Hardware and Software
 - 2. Cabling and Powering
- C. System Issues
 - 1. IP Addresses
 - 2. SIP Registration
- D. Network Issues
 - 1. LAN
 - 2. WAN
- E. Testing and Monitoring
 - 1. Fault Sectionalization
 - 2. Network Device Audit
 - 3. Testing Delay, Jitter, Packet Loss
 - 4. Monitoring and Proactive Maintenance
- F. Tips for Maximizing Voice Quality

Bonus! All students receive a large printed poster explaining VoIP call quality metrics and thresholds. Besides being cool cubicle wall covering, it provides a lot of useful information!

PART 3: THE NETWORK

9. ORGANIZING THE DISCUSSION

Much of the last day is devoted to understanding the modern 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 where they fit.

- A. The OSI Model
- B. The OSI Layers
- C. Protocol Stacks

10. ETHERNET ON COPPER, FIBER AND WIRELESS

Ethernet and its MAC frames are the building blocks of all new telecom networks, both in-building and between buildings. A VoIP phone plugs into a copper Ethernet LAN cable, or uses an Ethernet Wireless LAN to connect to the network. The network itself is built with point-to-point circuits conforming to the Optical Ethernet standard connecting equipment in different locations with fiber.

In this module, you will learn the basic principles of Ethernet and LANs, the crucial concepts of MAC addresses, MAC frames and broadcast domains, how devices connect via LAN switches, and how VLANs separate groups of users.

- 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 (WiFi)

11. IP ADDRESSES AND ROUTERS

Routers implement the network by relaying packets from one circuit to another. Determining *which* circuit to relay the packet to is the routing part of the story. In this module, you will fill in gaps, learn how IPv4 addresses are organized and how they are used to route packets between telephones during a VoIP phone call. We'll cover DHCP, static vs. dynamic addresses, public vs. private addresses, NAT and how ARP relates Ethernet to IP. To be ready for the future, we'll finish with a review of the IPv6 address structure and usage.

- A. IPv4 Address Classes
- B. CIDR: Prefix and Subnet Mask
- C. DHCP, Static and Dynamic Addresses
- D. IP Network Example: Routers Connected with Dedicated Lines
- E. Routers and Packet Filtering
- F. Sending a Packet: Address Resolution Protocol
- G. Public and Private IPv4 Addresses
- H. Network Address Translation
- 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. TCP, UDP AND PORTS

You will learn that IP does not come with any guarantees. There is no guarantee a packet will be delivered. Nada. To be sure a packet gets delivered, we use TCP or UDP. Plus, we'll demystify a second piece of information that sneaks in with TCP and UDP: ID of the computer program you want to talk to. This ID is called the *port number*.

- A. Unreliable Network Service
- B. Certified Mail
- C. TCP vs. UDP
- D. What is a Port?
- E. Well-Known Ports
- F. SIP Port and Media Port

13. IP NETWORK QUALITY: COS, QOS, MPLS AND SLAs

You will also learn that IP networks do not come with any performance guarantees: *when* the next packet will be transmitted, and how often that might happen... but banks, other carriers, government and other large organizations need guarantees. Guaranteed IP packet data communications between locations is called a *VPN* or *MPLS service*. We'll demystify and sort out quality of service, Class of Service (CoS), Service Level Agreement (SLA) and MPLS.

- A. Carrier Networks
- B. MPLS
- C. Class of Service Guarantees
- D. Service Level Agreement
- E. MPLS Services

Group Exercise: Open-book group collaboration final exam: Full VoIP Protocol Stack

At this point is the in-class Final Exam. The good news: it is done in groups, open book.

Determine the full VoIP protocol stack, identifying information needed at each of the 7 layers for a VoIP – VoIP telephone call. Exam format: fill in the blanks on a diagram of a protocol stack.

This requires understanding all of the pieces involved in moving a telephone call in IP packets from one person to another, touching on everything covered in the course.

Everyone participating in the in-class group-collaboration open-book final exam will receive a course completion certificate. Those who write the optional online CVA exam after the class will also receive TCO Certified VoIP Analyst certification.

PART 4: PROJECT MANAGEMENT

14. VOIP MIGRATION PROJECT STEPS, TIPS AND TRICKS

The final module is a template for managing a VoIP project, with detailed checklists in the course book. Going through the template, you'll learn how to do it the "right" way, from analyzing requirements to running trials, evaluating and selecting a vendor, rollout, acceptance testing and more. This project management guide is packed with practical tips and checklists to put to immediate use. If you are about to embark on a VoIP deployment, this might well be worth the price of the course all on its own!

- A. The Need for a Process
 - 1. Requirements before design before product purchase
- B. Dealing with Vendors
 - 1. Who is in charge here?
 - 2. Sales techniques to beware of
- C. Step 1: Internal Requirements Specification
- D. Step 2: Identify Potential Vendors
 - 1. Generating a Request for Information (RFI)
 - 2. Checklist: Who is providing what?
- E. Step 3: Qualify Vendors
- F. Step 4: Evaluate Qualified Vendors
 - 1. Setting up a captive test environment
 - 2. Trial their system
 - 3. Procedure: How to run tests and evaluate the results
- G. Step 5: Vendor Selection
 - 1. Generating a Request for Quote (RFQ)
 - 2. Reconciling the RFQ and the responses
 - 3. Dealing with unwanted features
- H. Step 6: Close the Deal
 - 1. Checklist: Core contract clauses and items that must be specified
 - 2. Negotiating the price
- I. Step 7: Roll Out the System
 - 1. Structured roll-out
 - 2. Leaving room for a roll-back
- J. Step 8: Maintenance
 - 1. Template: Trouble categories and response standards

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, with experience, tips and templates you can put to immediate use, as well as a certificate attesting to your IP telecom knowledge skills.

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

Space in our seminars is limited, and may sell out, so please register as early as possible to reserve your place. You can register online or by phone:

- [Register online at teracomtraining.com](http://www.teracomtraining.com)
- 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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In addition to scheduled public seminars, since 1992, we have provided high-quality on-site training at 3Com, Qualcomm, Intel, Cisco, Nortel, AT&T, Alcatel, Kyocera, T-Mobile, Ericsson/Hewlett-Packard, Verizon, MindSpring, APEX Telecom, Equifax, Transamerica Insurance, CNA Insurance, the US Air Force, Bell Canada, TELUS, Cap Gemini, ComSec Establishment, MicroCell, TDS Telecom, Western Wireless... to name a few.

Onsite training has special advantages:

- Your personnel will be up to a common speed with a solid knowledge base.
- We'll fill in the gaps and put in place productivity-enhancing structured understanding.
- The seminar will be a strong team-building exercise.
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We have built a solid reputation for delivering high-quality team-training programs that are a resounding success. Please contact us at 1-877-412-2700 or visit our web site for information on [onsite training](#).

About the Author



Eric Coll is an international expert in telecommunications, data communications and networking and has been actively involved in the industry since 1983. He holds Bachelor's and Master of Engineering (Electrical) degrees.

Mr. Coll has taught telecommunications technology training seminars to wide acclaim across North America since 1992, and has broad experience working as an engineer in the telecommunications industry.

He has worked for Nortel's R&D labs as a design engineer on projects including digital voice and data communications research and digital network equipment design; on satellite radar systems; Wide Area Network design, and many other projects in capacities ranging from detailed design and implementation to systems engineering, project leader and consultant.

Course Instructors



Richard Olsen, B.S.E.E., P.E. Richard Olsen holds a B.S. in Electrical Engineering and has over 36 years of professional engineering and teaching experience. Richard held senior management and engineering positions at Southwestern Bell for over 20 years. He has served as an instructor for numerous major companies as well as being an Adjunct Professor and Executive-in-Residence in the Master of Science in Telecommunications Management degree program, Oklahoma State University. Richard is a member of the MSTM Industry Advisory Board, Oklahoma State University, the National Society of Professional Engineers, the Oklahoma Society of Professional Engineers and the IEEE. Richard consistently receives

excellent ratings across the board on student evaluations, with many comments specifically praising his knowledge and thoroughness in making sure everyone understands the topics.



Jim Goughenour Jim has worked his way from installation and troubleshooting of DSL, LAN and WAN services to Senior Training Manager, Technical/Network at AT&T University, Charlotte, NC. Jim's knowledge, graduate degrees and certifications never stop growing. He is an expert in all things Cisco, IP, MPLS and AT&T's global network, and a Certified Trainer for (among others) the AT&T Uverse Curriculum, covering Uverse Fiber Networks, Uverse Technologies, Uverse Customer Premise Equipment, Uverse Wiring Skills and Enhanced Troubleshooting.