IP COMMUNICATIONS

Voice over IP Security

Security best practices derived from deep analysis of the latest VoIP network threats

ciscopress.com

Patrick Park

Voice over IP Security

Patrick Park

Copyright © 2009 Cisco Systems, Inc.

Published by:
Cisco Press
800 East 96th Street
Indianapolis, IN 46240 USA

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without written permission from the publisher, except for the inclusion of brief quotations in a review.

Printed in the United States of America

First Printing September 2008

Library of Congress Cataloging-in-Publication data

Park, Patrick, 1971-

Voice over IP security / Patrick Park.

p. cm.

ISBN 978-1-58705-469-3 (pbk.)

1. Internet telephony--Security measures. I. Title. II. Title: VoIP security.

TK5105.8865.P37 2008

004.69'5--dc22

2008036070

ISBN-13: 978-1-58705-469-3

ISBN-10: 1-58705-469-8

Warning and Disclaimer

This book is designed to provide information about Voice over IP security. Every effort has been made to make this book as complete and as accurate as possible, but no warranty or fitness is implied.

The information is provided on an "as is" basis. The authors, Cisco Press, and Cisco Systems, Inc. shall have neither liability nor responsibility to any person or entity with respect to any loss or damages arising from the information contained in this book or from the use of the discs or programs that may accompany it.

The opinions expressed in this book belong to the author and are not necessarily those of Cisco Systems, Inc.

Trademark Acknowledgments

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. Cisco Press or Cisco Systems, Inc., cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

Corporate and Government Sales

The publisher offers excellent discounts on this book when ordered in quantity for bulk purchases or special sales, which may include electronic versions and/or custom covers and content particular to your business, training goals, marketing focus, and branding interests. For more information, please contact: **U.S. Corporate and Government Sales** 1-800-382-3419 corpsales@pearsontechgroup.com

For sales outside the United States please contact: **International Sales** international@pearsoned.com

Feedback Information

At Cisco Press, our goal is to create in-depth technical books of the highest quality and value. Each book is crafted with care and precision, undergoing rigorous development that involves the unique expertise of members from the professional technical community.

Readers' feedback is a natural continuation of this process. If you have any comments regarding how we could improve the quality of this book, or otherwise alter it to better suit your needs, you can contact us through email at feedback@ciscopress.com. Please make sure to include the book title and ISBN in your message.

We greatly appreciate your assistance.

Publisher	Paul Boger
Associate Publisher	Dave Dusthimer
Cisco Press Program Manager	Jeff Brady
Executive Editor	Brett Bartow
Managing Editor	Patrick Kanouse
Development Editor	Dan Young
Project Editor	Seth Kerney
Copy Editor	Margaret Berson
Technical Editors	Bob Bell
	Dan Wing
Editorial Assistant	Vanessa Evans
Designer	Louisa Adair
Composition	Octal Publishing, Inc.
Indexer	WordWise Publishing Services LLC
Proofreader	Water Crest Publishing, Inc.

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
168 Robinson Road
#28-01 Capital Tower
Singapore 068912
www.cisco.com
Tel: +65 6317 7777
Fax: +65 6317 7799

Europe Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: +31 0 800 020 0791
Fax: +31 0 20 357 1100

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at **www.cisco.com/go/offices.**

©2007 Cisco Systems, Inc. All rights reserved. CCVP, the Cisco logo, and the Cisco Square Bridge logo are trademarks of Cisco Systems, Inc.; Changing the Way We Work, Live, Play, and Learn is a service mark of Cisco Systems, Inc.; and Access Registrar, Aironet, BPX, Catalyst, CCDA, CCDP, CCIE, CCIP, CCNA, CCNP, CCSP, Cisco, the Cisco Certified Internetwork Expert logo, Cisco IOS, Cisco Press, Cisco Systems, Cisco Systems Capital, the Cisco Systems logo, Cisco Unity, Enterprise/Solver, EtherChannel, EtherFast, EtherSwitch, Fast Step, Follow Me Browsing, FormShare, GigaDrive, GigaStack, HomeLink, Internet Quotient, IOS, IP/TV, iQ Expertise, the iQ logo, iQ Net Readiness Scorecard, iQuick Study, LightStream, Linksys, MeetingPlace, MGX, Networking Academy, Network Registrar, Packet, PIX, ProConnect, RateMUX, ScriptShare, SlideCast, SMARTnet, StackWise, The Fastest Way to Increase Your Internet Quotient, and TransPath are registered trademarks of Cisco Systems, Inc. and/or its affiliates in the United States and certain other countries.

All other trademarks mentioned in this document or Website are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (0609R)

Introduction

Voice over Internet Protocol (VoIP) has been popular in the telecommunications world since its emergence in the late 90s, as a new technology transporting multimedia over the IP network. In this book, the multimedia (or rich media) includes not only voice, but also video, instant message, presence data, and fax data over the IP network.

Today people commonly make phone calls with IP phones or client software (such as Skype or iChat) on their computer, or send instant messages to their friends. This gives them convenience and cost savings. Many telecommunications companies and other organizations have been switching their legacy phone infrastructure to a VoIP network, which reduces costs for lines, equipment, manpower, and maintenance.

However, the benefits of VoIP are not free. There are disadvantages to using VoIP. The integrated rich media makes it difficult to design the network architecture. Multiple VoIP protocols and different methods of implementation create serious interoperability issues. Integration with existing data networks creates quality of service issues. The fact that so many network elements are involved through open (or public) networks creates serious security issues, because each element and network has vulnerable factors.

The security issues especially are becoming more serious because traditional security devices (such as firewalls) and protocols (such as encryption) cannot protect VoIP services or networks from recent intelligent threats.

This book focuses on the important topic of VoIP security by analyzing current and potential threats to demonstrating the methods of prevention.

Goals and Methods

The most important goal of this book is to give you correct and practical answers for the following questions:

- What are the current and potential threats?
- What are the impacts of those threats?
- Why are current data security devices not able to protect against recent intelligent threats?
- How can you protect VoIP services and networks from those threats?
- What is lawful interception and how do you implement it?

One key methodology used in this book is to give you hands-on experience of current well-known threats by simulating them with publicly available tools. Through the simulation, you can realize the characteristics and impacts of those threats and have a better understanding of mitigation.

Another key methodology is to give you detailed examples of protection methods with protocols, products, and architecture so that you may apply them to real VoIP service environments.

This book also gives you clarification of VoIP security concepts, definitions, standards, requirements, limitations, and related terms.

Who Should Read This Book

This book is NOT designed to give you information about VoIP in general which is available almost everywhere. Instead, this book focuses on VoIP security and gives practical information to people like those in the following list:

- Managers or engineers who are planning to employ VoIP systems in their organizations
- System engineers or architects who design and implement VoIP networks
- Network administrators who administer, upgrade, or secure networks that include VoIP elements
- Security consultants who perform security assessments for VoIP environments
- Developers who implement VoIP products or solutions
- Researchers and analysts who are interested in VoIP security

This book assumes that the readers have some minimal knowledge of networking (such as TCP/IP), operating systems, and VoIP in general (such as IP phones).

How This Book Is Organized

Although this book could be read cover to cover, it is designed to be flexible and allow you to easily move between chapters and sections of chapters to cover just the material that you need more work with.

This book consists of three parts. Part I, "VoIP Security Fundamentals," contains Chapters 1 through 5 and covers VoIP security fundamentals that are essential to understand current threats and security practices. Part II, "VoIP Security Best Practices," contains Chapters 6 through 9 and demonstrates VoIP security best practices with the detailed analysis and simulation of current threats. Part III, "Lawful Interception (CALEA)," contains Chapters 10 through 11 and covers another aspect of VoIP security, Lawful Interception, from basic concept to real implementation.

Chapter 1, "Working with VoIP," provides an overview of VoIP and its vulnerability in general. Chapters 2 through 11 are the core chapters and can be read in any order. If you do intend to read them all, the order in the book is an excellent sequence to use.

The core chapters, Chapters 2 through 11, cover the following topics:

- **Chapter 2, "VoIP Threat Taxonomy"**—This chapter defines VoIP threat taxonomy, based on four different categories: threats against availability, confidentiality, integrity, and social context. This chapter is not intended to provide exhaustive lists of current and potential threats, but to define the taxonomy for identifying the threat in the first place, measuring the current and potential impact, and helping implementers to develop protection methods and secure service architecture. Twenty-two typical threats are introduced with examples and features.
- **Chapter 3, "Security Profiles in VoIP Protocols"**—This chapter introduces the security profiles of VoIP protocols: SIP, H.323, and MGCP. The content shows how each protocol defines specific security mechanisms and recommends combined solution with other security protocols, such as IPSec, TLS, and SRTP.

- **Chapter 4, "Cryptography"**—This chapter provides a high-level understanding of cryptographic algorithms with comprehensible figures, avoiding mathematical details. Well-known cryptographic algorithms are introduced, such as DES, 3DES, AES, RAS, DSA, and hash functions (MD5, SHA, and HMAC). This chapter also covers the mechanism of key management, focusing on key distribution.
- **Chapter 5, "VoIP Network Elements"**—This chapter covers what devices are involved in the VoIP network architecture, and how they work for secure services. Session Border Controller, VoIP-aware firewalls, NAT servers, lawful interception servers, customer premise equipment, call processing servers, and media gateways are introduced.
- **Chapter 6, "Analysis and Simulation of Current Threats"**—This chapter covers two main topics: detailed analysis and hands-on simulation of most common threats, and the guidelines for mitigation. For the analysis, it examines the detailed patterns, usage examples, and impacts of the threats. For the simulation, it introduces negative testing tools that are available on the Internet so that you can have hands-on experience. The threats that this chapter covers are DoS, malformed messages, sniffing (eavesdropping), spoofing (identity theft), and VoIP spam (voice, instant message, and presence spam).
- **Chapter 7, "Protection with VoIP Protocol"**—This chapter demonstrates the details of how to make VoIP service secure with SIP and other supplementary protocols. It focuses on the methodology of protection in these five categories: authentication, encryption, transport and network layer security, threat model and prevention, and limitations.
- **Chapter 8, "Protection with Session Border Controller"**—This chapter examines security issues on the VoIP network borders, and provides the methodology of preventing the issues with an SBC. This chapter includes the details of SBC functionality (such as network topology hiding, DoS protection, overload prevention, NAT traversal, and lawful interception), as well as the method of designing service architecture with an SBC in terms of high availability, secure network connectivity, virtualization, and optimization of traffic flow.
- **Chapter 9, "Protection with Enterprise Network Devices"**—This chapter demonstrates how to protect the enterprise VoIP network with Cisco devices for practical information. Cisco firewalls, Unified Communications Manager, Unified Communications Manager Express, IP phone, and multilayer switches are used. This chapter includes security features, usage examples, and configuration guidelines for those devices.
- **Chapter 10, "Lawful Interception Fundamentals"**—This chapter covers the fundamentals of lawful interception. The topics are definition, background information, requirements from law enforcement agents, the reference model from an architectural perspective, functional specifications, request/response interface, and operational considerations.
- **Chapter 11, "Lawful Interception Implementation"**—This chapter demonstrates how to implement lawful interception into the VoIP service environment. It focuses on how the interception request and response work between functional modules, based on industry specifications.

CHAPTER 2

VoIP Threat Taxonomy

The VoIP vulnerabilities that were introduced in Chapter 1, "Working with VoIP," can be exploited to create many different kinds of threats. Attackers may disrupt media service by flooding traffic, collect privacy information by intercepting call signaling or call content, hijack calls by impersonating servers or impersonating users, make fraudulent calls by spoofing identities, and so on.

Spammers may utilize VoIP networks to deliver spam calls, instant messages, or presence information, which are more effective than email spams because it is very difficult to filter VoIP spam.

This chapter is not intended to provide exhaustive lists of current and potential threats, but to define the taxonomy for the following purposes:

- To identify the threat in the first place
- To measure the current impact and potential future impact of the threat
- To help develop the protection method and design a secure service architecture

NOTE For an exhaustive list of all current and potential threats, go to www.voipsa.org (Voice over IP Security Alliance).

There are many possible ways to categorize the threats. This book uses the following four categories that most VoIP threats can belong to:

- Threats against availability
- Threats against confidentiality
- Threats against integrity
- Threats against social context

Each section in this chapter covers each category with typical threat examples. To give you a better understanding, each section uses figures and protocol examples with Session Initiation Protocol (SIP).

NOTE This chapter approaches these threats at a high level, focusing on the taxonomy. If you want to see a detailed analysis with simulation, refer to Chapter 6, "Analysis and Simulation of Current Threats."

The following section introduces the most critical threats that impact service availability.

Threats Against Availability

Threats against availability are actually a group of threats against service availability that is supposed to be running 24/7 (24 hours, 7 days a week). That is, these threats aim at VoIP service interruption, typically in the form of Denial of Service (DoS).

The typical threats against availability are as follows:

- Call flooding
- Malformed messages (protocol fuzzing)
- Spoofed messages (call teardown, toll fraud)
- Call hijacking (registration or media session hijacking)
- Server impersonating
- Quality of Service (QoS) abuse

The following subsections describe the threats with examples, which show you how they impact service availability.

Call Flooding

The typical example of DoS is intentional call flooding; an attacker floods valid or invalid heavy traffic (signals or media) to a target system (for example, VoIP server, client, and underlying infrastructure), and drops the performance significantly or breaks down the system. The typical methods of flooding are as follows:

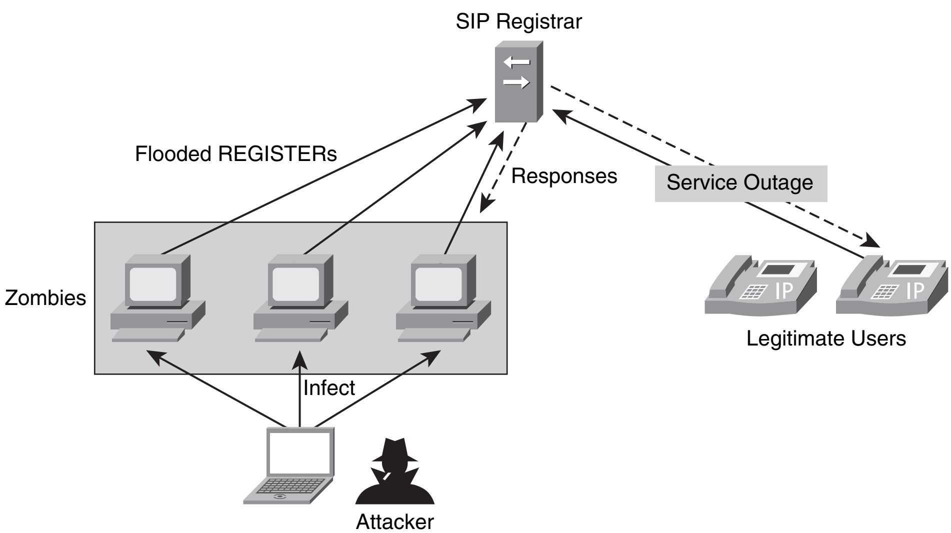
- **Valid or invalid registration flooding**—An attacker uses this method commonly because most registration servers accept the request from any endpoints in the public Internet as an initial step of authentication. Regardless of whether the messages are valid or invalid, the large number of request messages in a short period of time (for example, 10,000 SIP REGISTER messages per second) severely impacts the performance of the server.
- **Valid or invalid call request flooding**—Most VoIP servers have a security feature that blocks flooded call requests from unregistered endpoints. So, an attacker registers first after spoofing a legitimate user, and then sends flooded call requests in a short

period of time (for example, 10,000 SIP INVITE messages per second). This impacts the performance or functionality of the server regardless of whether the request message is valid or not.

- **Call control flooding after call setup**—An attacker may flood valid or invalid call control messages (for example, SIP INFO, NOTIFY, Re-INVITE) after call setup. Most proxy servers are vulnerable because they do not have a security feature to ignore and drop those messages.
- **Ping flooding**—Like Internet Control Message Protocol (ICMP) ping, VoIP protocols use ping messages in the application layer to check out the availability of a server or keep the pinhole open in the local Network Address Translation (NAT) server, such as SIP OPTIONS message. Most IP network devices (for example, a router or firewall) in the production network do not allow ICMP pings for security reasons. However, many VoIP servers should allow the application-layer ping for proper serviceability, which could be a critical security hole.

Figure 2-1 illustrates the example of distributed flooding with zombies; an attacker compromises other computers with malware (for example, a virus) and uses them as zombies flooding registration messages. Each zombie sends 1,000 SIP REGISTER messages per second with different credentials that are randomly generated.

Figure 2-1 *Call Flooding Example*



In Figure 2-1, the flooded messages will impact the registration server (SIP Registrar) severely as long as the server processes and replies with any error codes, such as "401 Unauthorized," "404 Not Found," "400 Bad Request," and so on. The impact can be high resource consumption (for example, CPU, memory, network bandwidth), system malfunction, or service outage. Whether the server responds or not, flooding the SIP registrar with sufficient registration messages will result in the degradation of service to the legitimate endpoints.

Not only the intentional flooding just mentioned, but also unintentional flooding exists in VoIP networks, so-called “self-attack,” because of incorrect configuration of devices, architectural service design problems, or unique circumstances. Here are some examples:

- **Regional power outage and restoration**—When the power is backed up after a regional outage, all endpoints (for example, 10,000 IP phones) will boot up and send registration messages to the server almost at the same time, which are unintentional flooded messages. Because those phones are legitimate and distributed over a wide area, it is hard to control the flooding traffic proactively.
- **Incorrect configuration of device**—The most common incorrect configuration is setting endpoint devices (for example, IP phones) to send too many unnecessary messages, such as a registration interval that is too short.
- **Misbehaving endpoints**—Problematic software (firmware) or hardware could create unexpected flooding, especially when multiple or anonymous types of endpoints are involved in the VoIP service network.
- **Legitimate call flooding**—There are unusual days or moments when many legitimate calls are made almost at the same time. One example is Mother’s Day, when a lot of calls are placed in the United States. Another example is natural disasters (for example, earthquakes), when people within the area make a lot of calls to emergency numbers (for example, 911) and their family and friends make calls to the affected area at the same time.

Those types of intentional and unintentional call flooding are common and most critical threats to VoIP service providers, who have to maintain service availability continually.

The next type is another form of threat against service availability, by means of malformed messages.

Malformed Messages (Protocol Fuzzing)

An attacker may create and send malformed messages to the target server or client for the purpose of service interruption. A *malformed message* is a protocol message with wrong syntax. Example 2-1 shows an example with a SIP INVITE message.

NOTE Protocol fuzzing is another name for malformed messages. A small difference is that protocol fuzzing includes malicious messages that have correct syntax but break the sequence of messages, which may cause system error by making the state machine confused.

Example 2-1 *Malformed SIP INVITE Message*

```
Request-URI: aaaaaaaaa sip:1001@192.168.10.10 SIP/2.0
Message Header
     Via: SIP/2.0/UDP CAL-D600-5814.cc-
ntd1.example.com:5060;branch=z9hG4bK00002000005
     From::::::::: 2 <sip:user@CAL-D600-5814.cc-ntd1.example.com>;tag=2
     To: Receiver <sip:1001@192.168.10.10>
    Call-Id: 555555555555555555555-5555555555555555555555555555-55555555555555555-
           5555555-55555555555555555555-5555555555555-55555555555555555-555555555-
           555555555@CAL-D600-5814.cc-ntd1.example.com
     CSeq: 1 INVITE
     Contact: 2 <sip:user@CAL-D600-5814.cc-ntd1.example.com>
     Expires: 1200
     Max-Forwards: 70
     Content-Type: application/sdp
     Content-Length: 143

Message body
Session Description Protocol
     Session Description Protocol Version (v): = = = = = = 0
     Owner/Creator, Session Id (o): 2 2 2 IN IP4 CAL-D600-5814.cc-ntd1.example.com
     Session Name (s): Session SDP
     Connection Information (c): IN IP4 192.168.10.10
     Time Description, active time (t): 0 0
     Media Description, name and address (m): audio 9876 RTP/AVP 0
     Media Attribute (a): rtpmap:0 PCMU/8000
```

Note that the comments (bold letters) in Example 2-1 are not shown in the actual SIP INVITE message. You can find something wrong in the example of an INVITE message. Three SIP headers (Request-URI, From, and Call-Id) and one version in Session Description Protocol (SDP) have the wrong format.

The server receiving this kind of unexpected message could be confused (fuzzed) and react in many different ways depending on the implementation. The typical impacts are as follows:

- Infinite loop of parsing
- Buffer overflow, which may permit execution of arbitrary code
- Break state machine
- Unable to process other normal messages
- System crash

This vulnerability comes from the following sources in general:

1. Weakness of protocol specification

   Most VoIP protocols are open to the public and don't strictly define every single line. Attackers could find where the weakness of syntax is. Additionally, there are many customizable fields or tags.

2. Ease of creating the malformed message

   Creating a message like that in Example 2-1 is easy for regular programmers. Even for nonprogrammers, many tools are available to make customized messages.

3. Lack of exception handling in the implementation

   Because of time restrictions, most implementers are apt to focus on product features and interfaces, rather than create exception handling for massive negative cases.

4. Difficulty of testing all malformed cases

   It is very difficult to test all the negative cases, even though sophisticated testing tools covering more cases are coming out these days.

The threat of malformed messages should be preventable as long as the parsing algorithm handles them properly.

The next threat is spoofed messages that are not malformed but still impact service availability.

Spoofed Messages

An attacker may insert fake (spoofed) messages into a certain VoIP session to interrupt the service, or insert them to steal the session. The typical examples are "call teardown" and "toll fraud."

Call Teardown

The method of malicious call teardown is that an attacker monitors a SIP dialog and obtains session information (Call-ID, From tag, and To tag), and sends a call termination message (for example, SIP BYE) to the communication device while the users are talking. The device receiving the termination message will close the call session immediately. Figure 2-2 illustrates the example with SIP messages.

Figure 2-2 *Malicious Call Teardown*

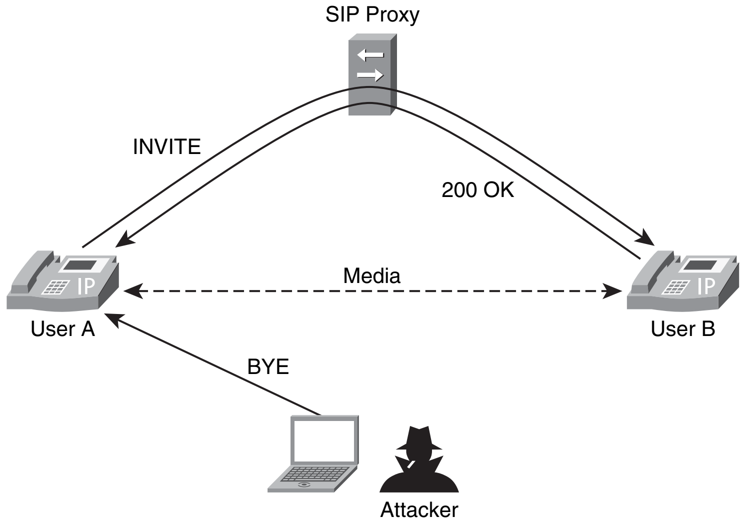


Figure 2-2 assumes that the attacker already monitored call signals between User A and B, and knew the session information (SIP dialog). The attacker injects the session information to the BYE message. The IP phone of user A receives the BYE and disconnects the media channel.

Another method of attack is that an attacker sends the termination messages to random devices (especially, proxy server) without knowing session information, which may affect current call sessions.

Compared to previous threats in this section, the malicious call teardown is not a common attack because the attacker should monitor the target call session before sending a termination message (BYE).

The next type of attack, toll fraud, also requires preliminary information like credentials before making fraud calls, but it happens commonly because of monetary benefit.

Toll Fraud

A fraudulent toll call is one of the common threats these days, especially for long distance or international calls. Because most mediation devices (for example, public switched telephone network [PSTN] media gateway, proxy server) require valid credentials (for example, ID and password) before setting up the toll call, an attacker collects the credentials first in many different ways. Typically, an attacker creates spoofed messages for brute-force password assault on the server until he receives authorization. If the clients use default passwords or easy-to-guess passwords, it is much easier to find them, especially when an attacker uses a password dictionary (see Note).

NOTE A *password dictionary* is a file that contains millions of frequently used passwords.

Most passwords are manually created by humans (rather than by computers), so it's highly likely that they will be simple and easy to remember. No one really wants to have to remember random passwords that are longer than 10 digits, except perhaps system administrators. For example, a user named John Kim is apt to have passwords such as "jkim," "iamjohn," "johnkim," "john2kim," "john4me," and so on. Therefore, an attacker using a password dictionary containing millions of commonly used passwords would not need much time to crack most user-created passwords.

In some cases, the server does not require the credentials, but checks out the source IP address or subnet of the client to control the access. Especially when call trunking (for example, SIP trunking) is set up between a VoIP service provider and an enterprise customer, access control based on the source IP or subnet is commonly used. An attacker may be able to access the server by spoofing the source IP address.

Call Hijacking

Hijacking occurs when some transactions between a VoIP endpoint and the network are taken over by an attacker.

The transactions can be registration, call setup, media flow, and so on. This hijacking can make serious service interruption by disabling legitimate users to use the VoIP service. It is similar to call teardown in terms of stealing session information as a preliminary, but the actual form of attack and impact are different.

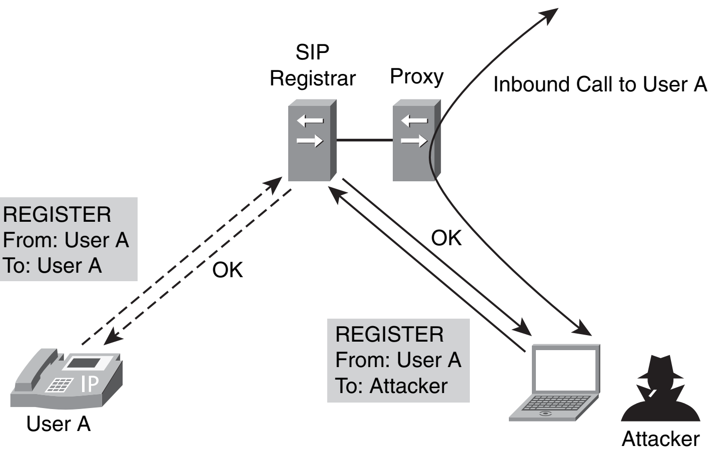
The typical cases are registration hijacking, media session hijacking, and server impersonating. The next few sections describe each of these cases.

Registration Hijacking

The registration process allows an endpoint to identify itself to the server (for example, SIP Registrar) as a device that a user is located.

An attacker monitors this transaction and sends spoofed messages to the server in order to hijack the session. When a legitimate user has been compromised, that user cannot receive inbound calls. Figure 2-3 illustrates the example with SIP messages.

Figure 2-3 *Registration Hijacking*



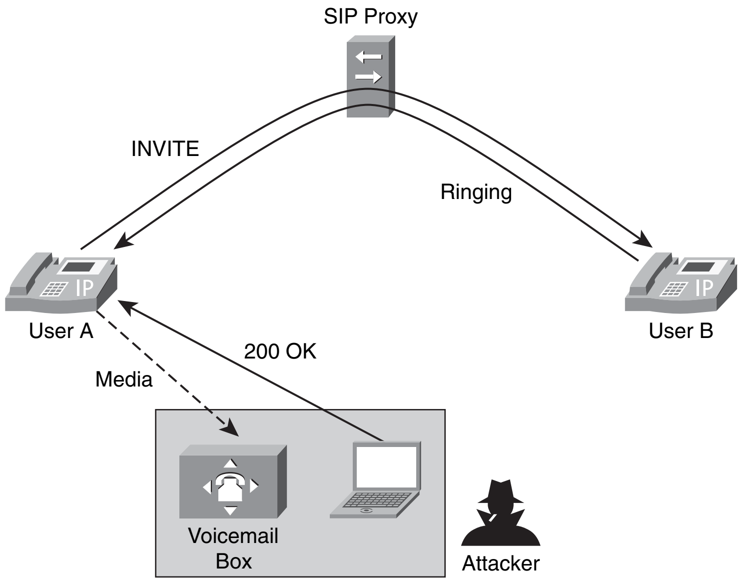
In Figure 2-3, an attacker impersonates a user agent by modifying the "From" header and adding the attacker's address to the "To" header when it sends a REGISTER message, which updates the address-of-record of the target user. All inbound calls to User A will be routed to the attacker.

This threat happens when the user agent server (Registrar) is relying on only SIP headers to identify the user agent.

Media Session Hijacking

When a media session is being negotiated between VoIP endpoints, an attacker may send spoofed messages to either one of them to redirect the media to another endpoint such as the attacker's phone or voicemail box. The victim will only be able to talk with the attacker's endpoint. Figure 2-4 illustrates the example with SIP messages.

Figure 2-4 *Media Session Hijacking*



In Figure 2-4, User A tries to make a call to User B and the IP phone of User B is ringing. Having monitored call requests to User B, an attacker detects the call and sends 200 OK messages to User A with the IP/port address of the attacker's voicemail server. User A leaves a voice message for User B in the attacker's voicemail box. This hijacking happens before the media session is established between User A and (the intended) user B.

Even after the media session is established between A and B, an attacker can still hijack an active session by sending a Re-Invite message to User A.

Server Impersonating

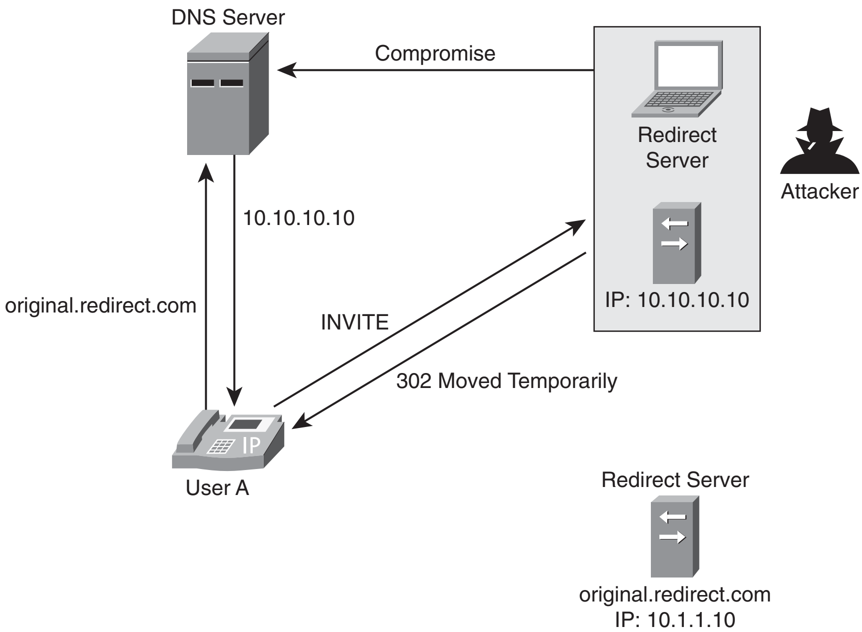
A VoIP client sends a request message to a server in the target domain for registration, call setup or routing, and so on. It is possible for an attacker to impersonate the server, receive the request message, and then manipulate it for malicious purposes.

The typical method of impersonating a server is attacking the local TFTP server or Domain Name Service (DNS) server as the initial step. An attacker may intrude into the TFTP server and replace the configuration file for IP phones with his file having an IP address of a malicious server (for example, SIP Registrar).

The IP phones downloading the malicious file will send a request message to the wrong server.

An attacker may also compromise the DNS server and replace the entry of current VoIP server with an IP address of a malicious server. The IP phones looking up the server IP will receive a wrong one. Figure 2-5 illustrates an example based on SIP transactions with a Redirect server.

Figure 2-5 *Server Impersonating*



In Figure 2-5, the attacker compromised the local DNS server first by replacing the IP address (10.1.1.10) of original.redirect.com with 10.10.10.10, which is the attacker's redirect server.

When User A tries to make a call to User B, the IP phone looks up the IP address of the redirect server (original.redirect.com) and receives the IP (10.10.10.10) of the impersonated server. The INVITE message is sent to the impersonated server, and it replies "302 Moved Temporarily" with wrong contact information that could be a dummy address or attacker's proxy server for further threat. The original redirect server (10.1.1.10) cannot receive any call request in this situation.

QoS Abuse

The elements of a media session are negotiated between VoIP endpoints during call setup time, such as media type, coder-decoder (codec) bit rate, and payload type. For example, it may be necessary or desirable to use G.729 when leaving a network (to conserve bandwidth) but to use G.711 when calls are staying inside a network (to keep call quality higher). An attacker may intervene in this negotiation and abuse the Quality of Service (QoS), by replacing, deleting, or modifying codecs or payload type.

Another method of QoS abuse is exhausting the limited bandwidth with a malicious tool so that legitimate users cannot use bandwidth for their service. Some VoIP service providers or hosting companies limit the bandwidth for certain groups of hosts to protect the network. An attacker may know the rate limit and generate excessive media traffic through the channel, so voice quality between users may be degraded.

In this section so far, you have learned about threats against availability, such as call flooding, malformed messages, spoofed messages (call teardown, toll fraud), call hijacking (registration and media session hijacking, server impersonating), and QoS abuse. The next section covers another type of threat: attacks against call data and media confidentiality.

Threats Against Confidentiality

Another category of VoIP threat is the threat against confidentiality.

Unlike the service interruptions in the previous section, threats against confidentiality do not impact current communications generally, but provide an unauthorized means of capturing media, identities, patterns, and credentials that are used for subsequent unauthorized connections or other deceptive practices.

VoIP transactions are mostly exposed to the confidentiality threat because most VoIP service does not provide full confidentiality (both signal and media) end-to-end. In fact, full encryption of message headers is not possible because intermediary servers (for example, SIP proxy server) have to look at the headers to route the call. In some cases, the servers have to insert some information into the header (for example, Via header in SIP) as the protocol is designed.

This section introduces the most popular types of confidentiality threats: eavesdropping media, call pattern tracking, data mining, and reconstruction.

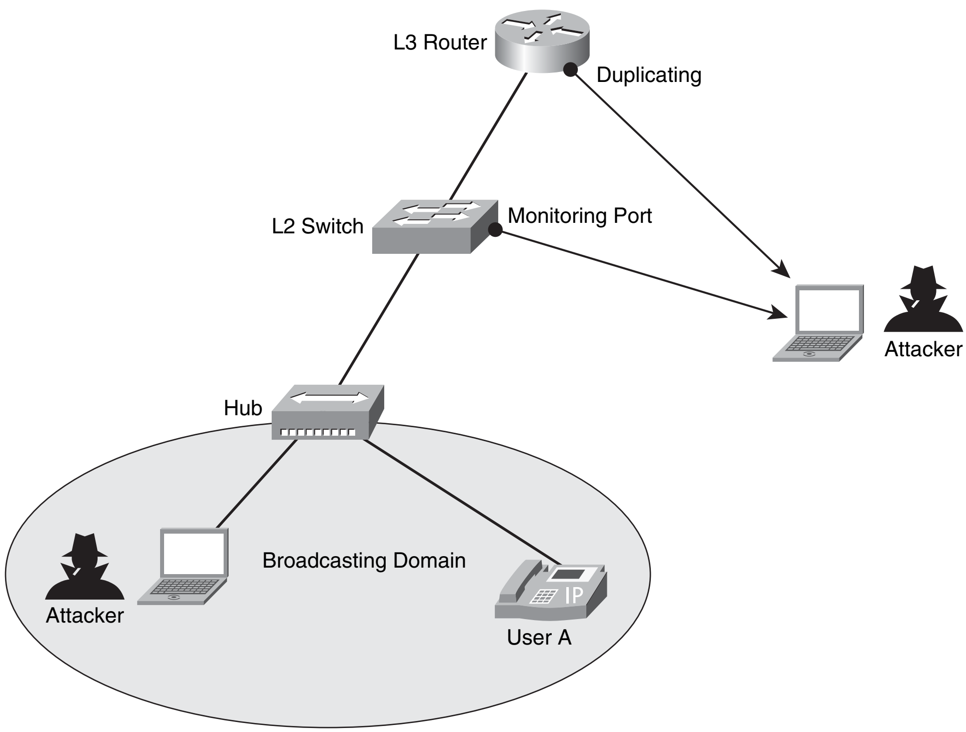
Eavesdropping Media

Eavesdropping on someone's conversation has been a popular threat since telecommunication service started a long time ago, even though the methods of eavesdropping are different between legacy phone systems and VoIP systems.

In VoIP, an attacker uses two methods typically. One is sniffing media packets in the same broadcasting domain as a target user's, or on the same path as the media. The other is compromising an access device (for example, Layer 2 switch) and forwarding (duplicating) the target media to an attacker's device.

The media can be voice-only or integrated with video, text, fax, or image. Figure 2-6 illustrates these cases.

Figure 2-6 *Eavesdropping Media*



In Figure 2-6, the attacker's device that is in the same broadcasting domain as the IP phone of User A can capture all signals and media through the hub. This figure also shows the possibility that the attacker intrudes in a switch or router, and configures a monitoring port for voice VLAN, and forwards (duplicates) the media to the attacker's capturing device.

Another possible way of eavesdropping media is that an attacker taps the same path as the media itself, which is similar to legacy tapping technique on PSTN. For example, the attacker has access to the T1 itself and physically splits the T1 into two signals.

Although this technique is targeting media, the next method (call pattern tracking) is targeting signal information.

Call Pattern Tracking

Call pattern tracking is the unauthorized analysis of VoIP traffic from or to any specific nodes or network so that an attacker may find a potential target device, access information (IP/port), protocol, or vulnerability of network. It could also be useful for traffic analysis—knowing who called who, and when. For example, knowing that a company's CEO and CFO have been calling the CEO and CFO of another company could indicate that an acquisition is under way. For another example, knowing that a CEO called her stockbroker immediately after meeting with someone with insider stock knowledge is useful. That is, this is useful for learning about people and information.

To show an example of unauthorized analysis, sample messages that an attacker may capture in the middle of a network are illustrated in Example 2-2. It shows simple SIP request (INVITE) and response (200 OK) messages, but an attacker can extract a great deal of information from them by analyzing the protocol (key fields are highlighted).

Example 2-2 *Exposed Information from SIP Messages*

```
INVITE sip:9252226543@192.168.10.10:5060 SIP/2.0
Via: SIP/2.0/UDP 10.10.10.10:5060;branch=z9hG4bK00002000005
From: Alice <sip:4085251111@10.10.10.10:5060>;tag=2345
To: Bob <sip:9252226543@192.168.10.10>
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Contact: <sip:4085251111@10.10.10.10>
Expires: 1200
Max-Forwards: 70
Content-Type: application/sdp
Content-Length: 143

Session Description Protocol Version (v): = 0
Owner/Creator, Session Id (o): 2 2 2 IN IP4 10.10.10.10
Session Name (s): Session SDP
Connection Information (c): IN IP4 10.10.10.10
Media Description, name and address (m): audio 9876 RTP/AVP 0 8 18
Media Attribute (a): rtpmap:0 PCMU/8000
Media Attribute (a): rtpmap:8 PCMA/8000
Media Attribute (a): rtpmap:18 G729a/8000

============================================================
SIP/2.0 200 OK
Via: SIP/2.0/UDP 10.10.10.10:5060;branch=z9hG4bK00002000005
From: Alice <sip:4085251111@10.10.10.10:5060>;tag=2345
To: Bob <sip:9252226543@192.168.10.10>;tag=4567
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Contact: <sip:9252226543@172.26.10.10>
Content-Type: application/sdp
Content-Length: 131
```

Example 2-2 *Exposed Information from SIP Messages (Continued)*

```
Session Description Protocol Version (v): = 0
Owner/Creator, Session Id (o): 2 2 2 IN IP4 172.26.10.10
Session Name (s): Session SDP
Connection Information (c): IN IP4 172.26.10.10
Media Description, name and address (m): audio 20000 RTP/AVP 18
Media Attribute (a): rtpmap:18 G729a/8000
```

The following list shows sample information that the attacker may extract from Example 2-2:

- The IP address of the SIP proxy server is 192.168.10.10, and the listening port is 5060.
- They use User Datagram Protocol (UDP) packets for signaling without any encryption, such as Transport Layer Security (TLS) or Secure Multipurpose Internet Mail Extension (S/MIME).
- The proxy server does not require authentication for a call request.
- The caller (Alice), who has a phone number 4085251111, makes a call to Bob at 9252226543.
- The IP address of Alice's phone is 10.10.10.10 and a media gateway is 172.26.10.10 (supposing that the call goes to PSTN).
- The media gateway opens a UDP port, 20000, to receive Real-time Transport Protocol (RTP) stream from Alice's phone.
- The media gateway accepts only G.729a codec (Alice's phone offered G.711a, G.711u, and G.729a initially).

The information just presented can be used for future attacks, such as DoS attack on the proxy server or the media gateway.

Data Mining

Like email spammers who collect email addresses from various sources like web pages or address books, VoIP spammers also collect user information like phone numbers from intercepted messages, which is one example of data mining.

The general meaning of data mining in VoIP is the unauthorized collection of identifiers that could be user name, phone number, password, URL, email address, strings or any other identifiers that represent phones, server nodes, parties, or organizations on the network. In Example 2-2, you can see that kind of information from the messages.

An attacker utilizes the information for subsequent unauthorized connections such as:

- Toll fraud calls
- Spam calls (for example, voice, Instant Messaging [IM], presence spam)

- Service interruptions (for example, call flooding, call hijacking, and call teardown)
- Phishing (identity fraud; see the section "Threats Against Social Context" for more information)

With valid identities, attackers could have a better chance to interrupt service by sending many different types of malicious messages. Many servers reject all messages, except registration, unless the endpoint is registered.

Reconstruction

Reconstruction means any unauthorized reconstruction of voice, video, fax, text, or presence information after capturing the signals or media between parties. The reconstruction includes monitoring, recording, interpretation, recognition, and extraction of any type of communications without the consent of all parties. A few examples are as follows:

- Decode credentials encrypted by a particular protocol.
- Extract dual-tone multifrequency (DTMF) tones from recorded conversations.
- Extract fax images from converged communications (voice and fax).
- Interpret the mechanism of assigning session keys between parties.

These reconstructions do not affect current communications, but they are utilized for future attacks or other deceptive practices.

In this section so far, you have learned about threats against confidentiality such as eavesdropping media, call pattern tracking, data mining, and reconstruction. The next section covers another type of threats: breaking message and media integrity.

Threats Against Integrity

Another category of VoIP threat is the threat against integrity, which impacts current service severely in most cases.

The basic method of the integrity threat is altering messages (signals) or media after intercepting them in the middle of the network. That is, an attacker can see the entire signaling and media stream between endpoints as an intermediary. The alteration can consist of deleting, injecting, or replacing certain information in the VoIP message or media.

This section is divided into two types of threat at a high level:

- Threats against message integrity (message alteration)
- Threats against media integrity (media alteration)

The next section describes and gives examples of each type of threat.

Message Alteration

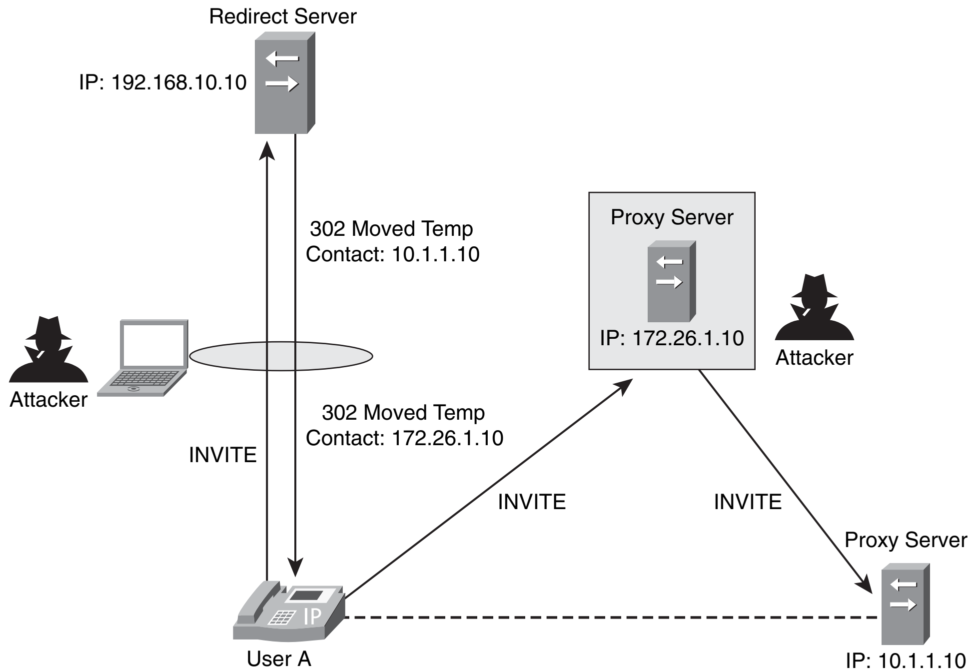
Message alteration is the threat that an attacker intercepts messages in the middle of communication entities and alters certain information to reroute the call, change information, interrupt the service, and so on. The typical examples are call rerouting and black holing.

Call Rerouting

Call rerouting is any unauthorized change of call direction by altering the routing information in the protocol message. The result of call rerouting is either to exclude legitimate entities or to include illegitimate entities in the path of call signal or media.

Figure 2-7 illustrates the example of including a malicious entity during call setup.

Figure 2-7 *Call Rerouting*



In Figure 2-7, an attacker keeps monitoring the call request message (for example, SIP INVITE) from User A to a redirect server. When User A initiates a call, the IP phone sends an INVITE message to the redirect server, as shown in Example 2-3.

Example 2-3 *IP Phone Sends an INVITE Message to the Redirect Server*

```
INVITE sip:Bob@192.168.10.10:5060 SIP/2.0
Via: SIP/2.0/UDP 10.10.10.10:5060;branch=z9hG4bK00002000005
From: UserA <sip:UserA@10.10.10.10:5060>;tag=2345
To: Bob <sip:Bob@192.168.10.10>
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Contact: <sip:UserA@10.10.10.10>
Max-Forwards: 70
Content-Length: 0
```

The attacker detects the INVITE and intercepts the response message (that is, "302 Moved Temporarily") from the redirect server, as shown in the continuation of Example 2-3.

```
SIP/2.0 302 Moved Temporarily
From: UserA <sip:UserA@10.10.10.10:5060>;tag=2345
To: Bob <sip:Bob@192.168.10.10>;tag=6789
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Contact: <sip:Bob@10.1.1.10>
Content-Length: 0
```

The attacker replaces the IP address of the proxy server (10.1.1.10) in the Contact header with his proxy server (172.26.1.10), and sends to the IP phone, as shown in the continuation of Example 2-3.

```
SIP/2.0 302 Moved Temporarily
From: UserA <sip:UserA@10.10.10.10:5060>;tag=2345
To: Bob <sip:Bob@192.168.10.10>;tag=6789
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Contact: <sip:Bob@172.26.1.10>
Content-Length: 0
```

The IP phone sends a new INVITE to attacker's proxy server rather than the legitimate server, and his server relays the message as shown in the picture. From now on, the attacker in the middle can see all signals between the endpoints and modify for any malicious purpose.

Call Black Holing

Call black holing is any unauthorized method of deleting or refusing to pass any essential elements of protocol messages, in the middle of communication entities. The consequence of call black holing is to delay call setup, refuse subsequent messages, make errors on applications, drop call connections, and so on. Here are a few examples with SIP:

1. An attacker as an intermediary drops only ACK messages between call entities so that the SIP dialog cannot be completed, even though there could be early media between them.

2 An attacker as an intermediary deletes media session information (SDP) in the INVITE message, which could result in one-way audio or call disconnection.

3 An attacker as an intermediary refuses to pass all messages to a specific user (victim) so that the user cannot receive any inbound calls.

The call rerouting and black holing belong to message alteration as previously described. The next section covers media alteration as part of the threat against integrity.

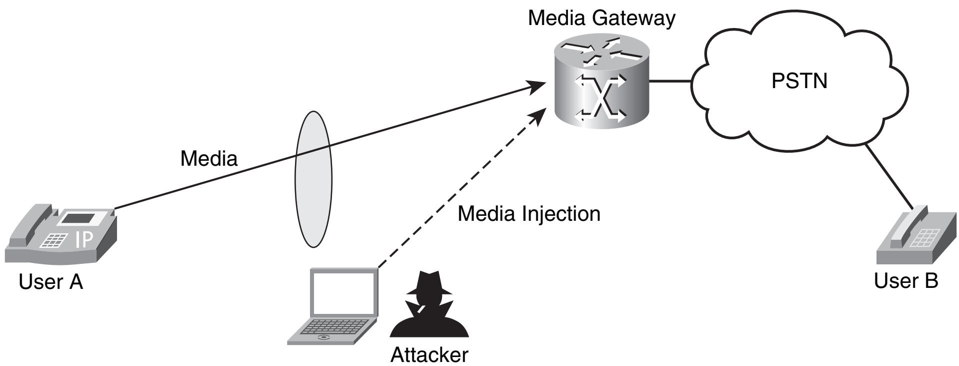
Media Alteration

Media alteration is the threat that an attacker intercepts media in the middle of communication entities and alters media information to inject unauthorized media, degrade the QoS, delete certain information, and so on. The media can be voice-only or integrated with video, text, fax, or image. The typical examples are media injection and degrading.

Media Injection

Media injection is an unauthorized method in which an attacker injects new media into an active media channel or replaces media in an active media channel. The consequence of media injection is that the end user (victim) may hear advertisement, noise, or silence in the middle of conversation. Figure 2-8 illustrates the example with voice stream.

Figure 2-8 *Media Injection*



In Figure 2-8, User A with an IP phone makes a call to User B who has a PSTN phone through a media gateway. After the call setup, the IP phone sends voice (RTP) packets to the media gateway. An attacker in the middle monitors the RTP sequence number of the voice packets, and adjusts the sequence number of illegitimate packets (for example, advertisements), and injects them into the voice channel so that they will arrive before the legitimate packets. User B in PSTN hears the injected voice.

Media Degrading

Media degrading is an unauthorized method in which an attacker manipulates media or media control (for example, Real-Time Control Protocol [RTCP]) packets and reduces the QoS of any communication. Here are a couple of examples:

1. An attacker intercepts RTCP packets in the middle, and changes (or erases) the statistic values of media traffic (packet loss, delay, and jitter) so that the endpoint devices may not control the media properly.
2. An attacker intercepts RTCP packets in the middle, and changes the sequence number of the packets so that the endpoint device may play the media with wrong sequence, which degrades the quality.

In this section so far, you have learned about VoIP threats against integrity such as message alteration (call rerouting, call black holing) and media alteration (media injection, media degrading). The next section covers another type of threats: social threats.

Threats Against Social Context

A threat against social context (as known as "social threat") is somewhat different from other technical threats against availability, confidentiality, or integrity, as previously discussed, in terms of the intention and methodology. It focuses on how to manipulate the social context between communication parties so that an attacker can misrepresent himself as a trusted entity and convey false information to the target user (victim).

The typical threats against social context are as follows:

- Misrepresentation of identity, authority, rights, and content
- Spam of call (voice), IM, and presence
- Phishing

NOTE A call with misrepresentation is initiated by an attacker who is a communication entity, which is different from the threats in the "Threats Against Integrity" section, which are based on interception and then modification.

The general meaning of spam is unsolicited bulk email that you may see every day. It wastes network bandwidth and system resources, as well as annoying email users. The spam exists in VoIP space as well, so-called VoIP spam, in the form of voice, IM, and presence spam. This section looks into each type of VoIP spam with SIP protocol. The content refers to RFC 5039.[1]

Phishing is becoming popular in the VoIP world these days as a method of getting somebody's personal information by deceiving the identity of an attacker.

The following sections give more details about these social threats.

NOTE These same types of attacks are equally available in today's PSTN environment.

Misrepresentation

Misrepresentation is the intentional presentation of a false identity, authority, rights, or content as if it were true so that the target user (victim) or system may be deceived by the false information. These misrepresentations are common elements of a multistage attack, such as phishing.

Identity misrepresentation is the typical threat that an attacker presents his identity with false information, such as false caller name, number, domain, organization, email address, or presence information.

Authority or rights misrepresentation is the method of presenting false information to an authentication system to obtain the access permit, or bypassing an authentication system by inserting the appearance of authentication when there was none. It includes presentation of password, key, certificate, and so on. The consequence of this threat could be improper access to toll calls, toll calling features, call logs, configuration files, presence information of others, and so on.

Content misrepresentation is the method of presenting false content as if it came from a trusted source of origin. It includes false impersonation of voice, video, text, or image of a caller.

Call Spam (SPIT)

Call (or voice) spam is defined as a bulk unsolicited set of session initiation attempts (for example, INVITE requests), attempting to establish a voice or video communications session. If the user should answer, the spammer proceeds to relay their message over real-time media. This is the classic telemarketer spam, applied to VoIP, such as SIP. This is often called SPam over IP Telephony, or SPIT.

The main reason SPIT is becoming popular is that it is cost-effective for spammers. As you know, legacy PSTN-call spam already exists in the form of telemarketer calls. Although these calls are annoying, they do not arrive in the same kind of volume as email spam. The difference is cost; it costs more for the spammer to make a phone call than it does to send email. This cost manifests itself in terms of the cost for systems that can perform telemarketer calls, and in cost per call. However, the cost is dramatically dropped when switching to

SPIT for many reasons: low hardware cost, low line cost, ease of writing a spam application, no boundary for international calls, and so on. Additionally, in some countries, such telemarketing calls over the PSTN are regulated.

In some cases, spammers utilize computational and bandwidth resources provided by others, by infecting their machines with viruses that turn them into "zombies" that can be used to generate call spam.

Another reason SPIT is getting popular is its effectiveness, compared to email spams. For email spams, you may already realize that there is a big difference between turning on and off a spam filter for your email account. In fact, most spam filters for email today work very well (filter more than 90 percent of spams) because of the nature of email; store and forward. All emails can be stored and examined in one place before forwarding to users. Even though users may still receive a small percentage of email spams, they usually look at profiles (for example, sender name and subject) and delete most of them without seeing the contents. However, the method of filtering emails does not work for SPIT because voice is real-time media. Only after listening to some information initially can users recognize whether it is a spam or not. So, spammers try to put main information in the initial announcement so that users may listen to it before hanging up the phone. There is a way to block those call attempts based on a blacklist (spammers' IP address or caller ID), but it is useless if spammers spoof the source information.

You can find more information on SPIT and mitigation methods in Chapter 6, "Analysis and Simulation of Current Threats."

The next topic is a different type of VoIP spam, IM spam.

IM Spam (SPIM)

IM spam is similar to email. It is defined as a bulk unsolicited set of instant messages, whose content contains the message that the spammer is seeking to convey. This is often called Spam over Instant Messaging, or SPIM.

SPIM is usually sent in the form of request messages that cause content to automatically appear on the user's display. The typical request messages in SIP are as follows:

- SIP MESSAGE request (most common)
- INVITE request with large Subject headers (since the Subject is sometimes rendered to the user)
- INVITE request with text or HTML bodies

Example 2-4 shows examples with SIP INVITE and MESSAGE.

Example 2-4 *IM Spam*

```
INVITE sip:Bob1@192.168.10.10:5060 SIP/2.0
Via: SIP/2.0/UDP 10.10.10.10:5060;branch=z9hG4bK00002000005
From: Spammer <sip:spammer1@10.10.10.10:5060>;tag=2345
To: Bob <sip:Bob1@192.168.10.10>
Call-Id: 9252226543-0001
CSeq: 1 INVITE
Subject: Hi there, buy a cool stuff in our website www.spam-example.com
Contact: <sip:spammer1@10.10.10.10>
Expires: 1200
Max-Forwards: 70
Content-Type: application/sdp
Content-Length: 143

======================================================================
MESSAGE sip:Bob1@192.168.10.10:5060 SIP/2.0
Via: SIP/2.0/UDP 10.10.10.10:5060;branch=z9hG4bK00002000005
From: Spammer <sip:spammer1@10.10.10.10:5060>;tag=2345
To: Bob <sip:Bob1@192.168.10.10>
Call-Id: 9252226543-0001
CSeq: 1 MESSAGE
Max-Forwards: 70
Content-Type: test/plain
Content-Length: 25

Hi there, buy a cool stuff in our website www.spam-example.com
```

SPIM is very much like email, but much more intrusive than email. In today's systems, IMs automatically pop up and present themselves to the user. Email, of course, must be deliberately selected and displayed.

Presence Spam (SPPP)

Presence spam is similar to SPIM. It is defined as a bulk unsolicited set of presence requests (for example, SIP SUBSCRIBE requests) in an attempt to get on the "buddy list" or "white list" of a user to subsequently send them IM or INVITEs. This is occasionally called SPam over Presence Protocol, or SPPP.

The cost of SPPP is within a small constant factor of IM spam, so the same cost estimates can be used here. What would be the effect of such spam? Most presence systems provide some kind of consent framework. A watcher that has not been granted permission to see the user's presence will not gain access to their presence. However, the presence request is usually noted and conveyed to the user, allowing them to approve or deny the request. This request itself can be spam, as shown in Example 2-5.

In SIP, this is done using the watcherinfo event package. This package allows a user to learn the identity of the watcher, in order to make an authorization decision. This could provide a vehicle for conveying information to a user; Example 2-5 shows the example with SIP SUBSCRIBE.

Example 2-5 *Presence Spam*

```
SUBSCRIBE sip:bob@example.com SIP/2.0
Event: presence
To: sip:bob@example.com
From: sip:buy-cool-dvds-and-games@spam-example.com
Contact: sip:buy-cool-dvds-and-games@spam-example.com
Call-ID: knsd08alas9dy@3.4.5.6
CSeq: 1 SUBSCRIBE
Expires: 3600
Content-Length: 0
```

A spammer in Example 2-5 generates the SUBSCRIBE request from the identity (sip:buy-cool-dvds-and-games@spam-example.com), and this brief message can be conveyed to the user, even though the spammer does not have permission to access presence. As such, presence spam can be viewed as a form of IM spam, where the amount of content to be conveyed is limited. The limit is equal to the amount of information generated by the watcher that gets conveyed to the user through the permission system.

Phishing

The general meaning of *phishing* is an illegal attempt to obtain somebody's personal information (for example, ID, password, bank account number, credit card information) by posing as a trust entity in the communication. In VoIP, phishing is typically happening through voice or IM communication, and voice phishing is sometimes called "vishing."

The typical sequence is that a phisher picks target users and creates request messages (for example, SIP INVITE) with spoofed identities, pretending to be a trusted party. When the target user accepts the call request, either voice or IM, the phisher provides fake information (for example, bank policy announcement) and asks for personal information. Some information like user name and password may not be directly valuable to the phisher, but it may be used to access more information useful in identity theft.

Here are a couple of phishing examples:

1. A phisher makes a call to a target user and leaves a voice message like: "This is an important message from ABC Bank. Because our system has changed, you need to change your password. Please call back at this number: 1-800-123-4567." When the target user calls the number back, the phisher's Interactive Voice Response (IVR) system picks up the call and acquires the user's password by asking "Please enter your current password for validation purposes . . .."

2 A phisher sends an instant text message to a smart phone (for example, PDA phone) or softphone (for example, Skype client) users, saying "This message is from ABC Bank. Your credit card rate has been increased. Please check it out on our website: http://www.abcbank.example.com." When the users click the URL, it goes to a phisher's website (example.com) that appears to have exactly the same web page that ABC Bank has. The fake website collects IDs and passwords that the users type in.

In this section, you have learned about VoIP threats in a social context, such as misrepresentation, call spamming, IM spamming, presence spamming and phishing. For more detailed information about VoIP spamming, refer to Chapter 6, "Analysis and Simulation of Current Threats."

Summary

VoIP vulnerabilities can be exploited to create many different kinds of threats. The threats can be categorized as four different types: threats against availability, confidentiality, integrity, and social context.

A threat against availability is a threat against service availability that is supposed to be running 24/7. That is, the threat is aiming at VoIP service interruption, typically, in the form of DoS. The examples are call flooding, malformed messages (protocol fuzzing), spoofed messages (call teardown, toll fraud), call hijacking (registration or media session hijacking), server impersonating, and QoS abuse.

A threat against confidentiality does not impact current communications generally, but provides an unauthorized means of capturing conversations, identities, patterns, and credentials that are used for the subsequent unauthorized connections or other deceptive practices. VoIP transactions are mostly exposed to the confidentiality threat because most VoIP service does not provide full confidentiality (both signal and media) end-to-end. The threat examples are eavesdropping media, call pattern tracking, data mining, and reconstruction.

A threat against integrity is altering messages (signals) or media after intercepting them in the middle of the network. That is, an attacker can see the entire signaling and media stream between endpoints as an intermediary. The alteration can consist of deleting, injecting, or replacing certain information in the VoIP message or media. The typical examples are call rerouting, call black holing, media injection, and media degrading.

A threat against social context focuses on how to manipulate the social context between communication parties so that an attacker can misrepresent himself as a trusted entity and convey false information to the target user. The typical examples are misrepresentation (identity, authority, rights, and content), voice spam, instant message spam, presence spam, and phishing.

End Notes

1 RFC 5039, "SIP and Spam," J. Rosenberg, C. Jennings, http://www.ietf.org/rfc/rfc5039.txt, January 2008.

References

"Phishing," Wikipedia, http://en.wikipedia.org/wiki/Phishing.

RFC 3261, "SIP (Session Initiation Protocol)," J. Rosenberg, H. Schulzrinne, G. Camarillo, A. Johnston, J. Peterson, R. Sparks, M. Handley, and E. Schooler, June 2002.

RFC 3428, "Session Initiation Protocol (SIP) Extension for Instant Messaging," B. Campbell, J. Rosenberg, H. Schulzrinne, C. Huitema, D. Gurle, December 2002.

Trammell, Dustin D. "VoIP Attacks," http://www.dustintrammell.com/presentations/.

"VoIP Security Threat Taxonomy," VOIPSA, http://www.voipsa.org/Activities/taxonomy-wiki.php.

INDEX

Numerics

A

E

F

G

H

I

K

L

M

N

O

P

S

T

U

V

W

Z