Wiretapping an entire Cisco VOIP environment

Exploiting the Call Manager

Hack.Lu 2013

Francisco

Plan

- **Introduction**
- Methodology
- Exploitation
- Demo
- Patch
- Conclusion

Introduction

Context

- Cisco VOIP environments are widely deployed
- Architecture composed of several elements
  - Hard phone: Cisco IP Phone
  - Soft phone: Cisco IP Communicator
  - Call manager: Cisco Unified Communications Manager

Fig.: Cisco IP Phone 7945g

Introduction

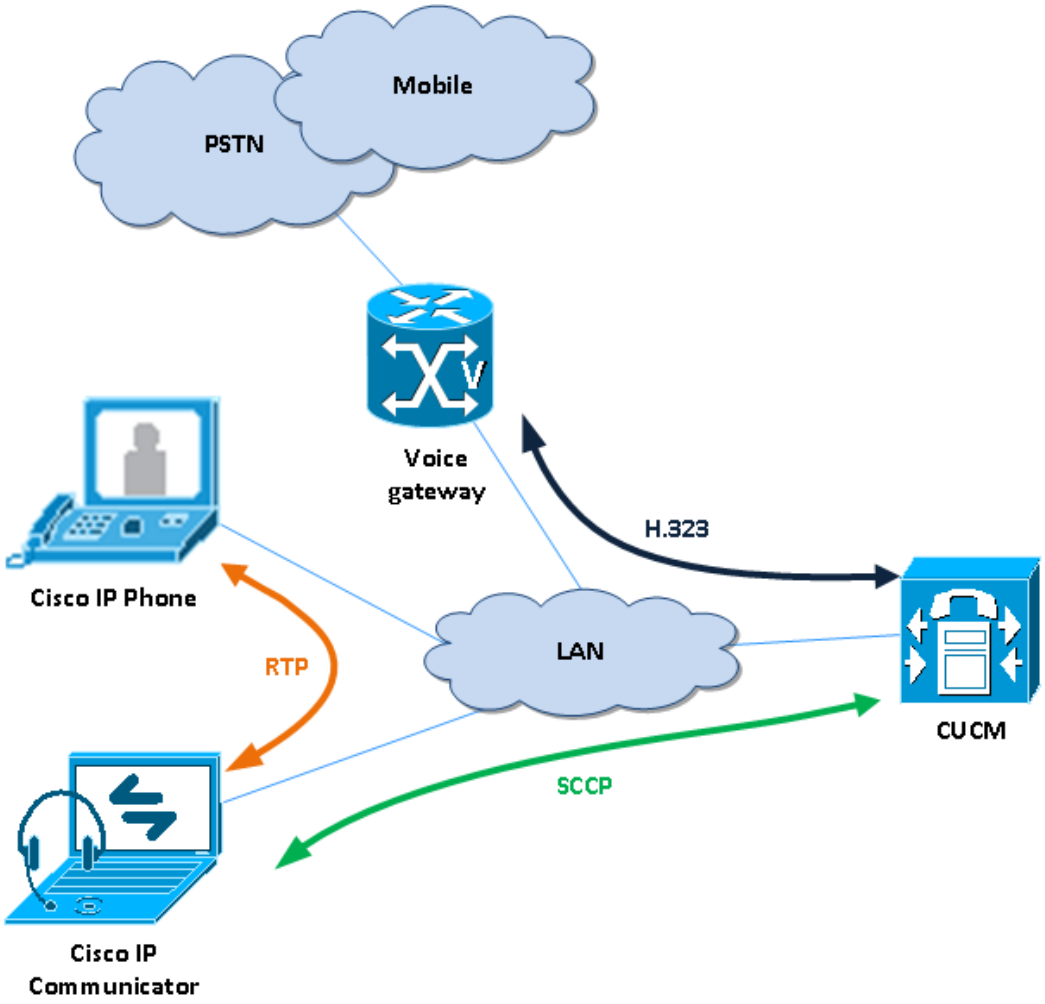

Fig.: Classic VOIP architecture

Introduction

Source	Destination	Protocol	Length	Info
10.228.224.3	10.228.247.8	SKINNY	202	StartMediaTransmission

```
▶ Frame 741: 202 bytes on wire (1616 bits), 202 bytes captured (1616 bits)
▶ Ethernet II, Src: [redacted]
▶ 802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 263
▶ Internet Protocol Version 4, Src: 10.228.224.3 (10.228.224.3), Dst: 10.228.247.8
▶ Transmission Control Protocol, Src Port: cisco-sccp (2000), Dst Port: 49354 (493
▼ Skinny Client Control Protocol
    Data length: 136
    Header version: CM7 type A (0x00000012)
    Message ID: StartMediaTransmission (0x0000008a)
    Conference ID: 49031119
    Pass-thru party ID: 35646659
    Remote IP address: 10.228.246.10 (10.228.246.10)
    Remote port: 24246
    MS/packet: 20
    Payload capability: G.722 64k (6)
```

Fig.: StartMediaTransmission SCCP packet

Introduction

Security

- More and more interest about the security:
  - *Hack.lu 2007*, Remote Wiretapping on Cisco Phones
  - *Black hat EU 2012*, All Your Calls are Still Belong to Us
  - *29c3 2012*, Hacking Cisco Phones

What about the Call manager?

- Critical component of the architecture
- Allows to administrate every phone
- Handles all SCCP traffic sent over the network:
  - Listen to all the VOIP network if root access obtained
  - Possibility to target a conversation instead of a person

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Methodology

Context

- Software Appliance based on a *Red Hat Enterprise Linux*
- File system access with the *vmware-mount* tool
- Add a SSH user and start the audit

Strategy

- A goal for each part…
- Black box audit: retrieve administrator credentials
- White box audit of the application: gain remote code execution
- Audit of the system: obtain privilege escalation

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Exploitation

Retrieving credentials

- Search for an sql injection in black box testing:
  - Modification of the phone's network parameters
  - Packet capture between Cisco Phone <> CUCM
  - Data validation tests

- Exploitation of the vulnerability:
  - *IBM Informix Dynamic Server 10.00.UC9XF*
  - Impossible to use the *FIRST* clause on that version
  - Execution of the query under the *dbadminweb* sql user
  - Retrieval of administrator credentials
  - Credentials are encrypted

Exploitation

Credentials encryption

- Done inside the java package *com.cisco.ccm.security*
- The method *CCMDecryption.decryptPassword* helps a lot:

```
try
{
  decryptor = JSAFE_SymmetricCipher.getInstance("AES128/CBC/PKCS5Padding", "Java");

  decryptor.setIV(encryptedPassword, 0, 16);
  byte[] temp = decryptor.getIV();

  byte[] encyPassword = new byte[encryptedPassword.length - 16];
  for (int j = 0; j < encryptedPassword.length - 16; j++) {
    encyPassword[j] = encryptedPassword[(16 + j)];
  }
  secretKey = decryptor.getBlankKey();
  secretKey.setSecretKeyData("Clear", keydata, 0, 16);
  decryptor.decryptInit(secretKey);
  recoveredText = new byte[encyPassword.length];
  int partOut = decryptor.decryptUpdate(encyPassword, 0, encyPassword.length, recoveredText, 0);

  int finalOut = decryptor.decryptFinal(recoveredText, partOut);
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Credentials encryption

- We can conclude the following elements:
  - AES encryption with a 128 bits key
  - CBC operation mode
  - PKCS5 padding method
  - IV stored in the first16 bytes
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- Where and how is stored the secret key *keydata*?

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- Where and how is stored the secret key *keydata*?
  - Key hardcoded in *com.cisco.ccm.security.CCMEncryption*
  - Same value for every CUCM installation

```
static
{
  keydata[0] = 115;  keydata[3] = 116;  keydata[6] = 115;  keydata[9] = 115;  keydata[12] = 99;
  keydata[1] = 109;  keydata[4] = 115;  keydata[7] = 111;  keydata[10] = 105; keydata[13] = 110;
  keydata[2] = 101;  keydata[5] = 121;  keydata[8] = 99;   keydata[11] = 99;  keydata[14] = 105;
```

Exploitation

Command execution

- Concerns the java package *com.cisco.ccm.admin.actions*
- Escape shell inside *BulkFileUploadAction.grantpermission:*

```
public boolean grantpermission(String theFilePath)
  throws InterruptedException
{
  boolean isSuccess = true;

  Process runMod = null;
  try
  {
    LOG.debug("in the grant permission function");

    String strcmd = "chmod 664 '" + theFilePath + "'";

    LOG.debug("in the grant permission function:the file path is:" + theFilePath);
    LOG.debug("cmd is::" + strcmd);

    runMod = Runtime.getRuntime().exec(new String[] { "/bin/bash", "-c", strcmd });

    runMod.waitFor();

    LOG.debug("Setting permissions: the exit value:" + runMod.exitValue());
```

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Command execution

- Several conditions to trigger the vulnerability:

```
String sqlsearch = "Select tbf.filelocation from typebatfunction as tbf where tbf.enum=" + functiontype;

rs = con1.executeQuery(sqlsearch);

String strFilePath = "";

if (rs.next())
{
  strFilePath = rs.getString("filelocation");
}
...
strFilePath = strFilePath + filename;
LOG.debug("In upload action1.the file path" + strFilePath);

this.fileexists = new File(strFilePath);
...
LOG.debug("In upload action: Instantiate the Writer to write to the file:location is:" + strFilePath);
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Command execution

- Requires the following conditions for being triggered:
  - Insertion of a row into the *typebatfunction* table
  - The *payload* used must be a valid full path

- Problem:
  - Stacked queries with the first sql injection?
  - Most sql queries are executed by *dbadminweb*
  - User having limited rights on the database
  - This user can not write to the *typebatfunction* table

```
GRANT SELECT, INSERT, UPDATE, DELETE on typebatfunction to database;
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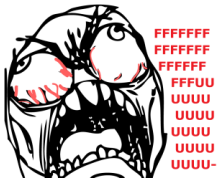

Exploitation

Obtaining *poweruser* rights

- Obtain a write access onto the *typebatfunction* table?
  - The sql user *dbims* has the *poweruser* role
  - Identification of the associated JDBC url

```
key="writeurl" value="jdbc:informix-sqli://...;user=dbims;"
```

- Identification of the sql queries executed in that context
- Discovery of a case that satisfies all the conditions:

```
protected static boolean updateFullCredential(String credOID, Boolean userCantChange, Boolean
  throws Exception
{
  ...
  try {
    conn = new DBConnector(DBConnector.getWriteUrl());

    String sql = "execute procedure ImsUpdateFullCredential";
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    if (credPolOID != null)
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Privilege escalation to *root*

- System command execution as *tomcat*
- Audit of the system to obtain *root* privileges
- Analysis of the */etc/sudoers* file:

```
$ cat /etc/sudoers |grep informix
informix ALL=(root) NOPASSWD: /usr/local/cm/bin/cisco_creve.pl
```

- What are the properties of the concerned file?

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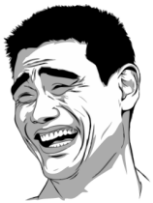
```

- What are the properties of the concerned file?
  - The *informix* user is also the owner of the script
  - Local root if we are able to obtain *informix* privileges

```
$ ls -lah /usr/local/cm/bin/cisco_creve.pl
-rwxr-xr-x informix informix 3.5K Oct  6 20:38 cisco_creve.pl
```



Exploitation

Privilege escalation to *informix*

- During the installation, execution of *sec_pwd_change.py*
- Password generation of several system users
- Derived from a random value stored in a file:

```
        f1 = open('/usr/local/cm/db/ifx.txt', 'w')
        f1.write(finalval)
...
        alphabet = "abcdefghijklmnopqrstuvwxyz"
        numalpha = "123456789" + alphabet
        mungedval = ""
        if finalval!= None:
            for c in finalval:
                i = alphabet.find(c)
                if i >= 0:
                    mungedval += numalpha[i]
...
            cmd = "echo '%s' | passwd --stdin -f informix" % (mungedval)
            rc = os.system(cmd)
```

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        f1 = open('/usr/local/cm/db/ifx.txt', 'w')
        f1.write(finalval)
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        alphabet = "abcdefghijklmnopqrstuvwxyz"
        numalpha = "123456789" + alphabet
        mungedval = ""
        if finalval!= None:
            for c in finalval:
                i = alphabet.find(c)
                if i >= 0:
                    mungedval += numalpha[i]
...
            cmd = "echo '%s' | passwd --stdin -f informix" % (mungedval)
            rc = os.system(cmd)
```

Exploitation

Privilege escalation to *informix*

- During the installation, execution of *sec_pwd_change.py*
- Password generation of several system users
- Derived from a random value stored in a file:

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...
            cmd = "echo '%s' | passwd --stdin -f informix" % (mungedval)
            rc = os.system(cmd)
```

- The file is world-readable and not removed:

```
$ cat /usr/local/cm/db/ifx.txt
313d8db76d5b
```

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- **Demo**
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Patch

Details

- Affected versions: 7.1(x), 8.5(x), 8.6(x), 9.0(x), 9.1(x)
- Cisco released the security advisory *cisco-sa-20130717-cucm*
- *"…a COP file that addresses the following vulnerabilities"*

Vulnerability	Patch
Sql injection (CVE-2013-3404)	Yes
Hardcoded secret key (CVE-2013-4869)	No
Post-auth sql injection with high privileges (CVE-2013-3412)	No
Command execution (CVE-2013-3402)	No
Privilege escalation to *informix* (CVE-2013-3403#1)	Yes
Privilege escalation to *root* (CVE-2013-3403#2)	Yes

Patch

- **CVE-2013-3404**
  - The first sql injection is patched
  - The vulnerable war is updated by a new one
  - By checking the war, we can see the patch is properly done

Patch

CVE-2013-3404

- The first sql injection is patched
- The vulnerable war is updated by a new one
- By checking the war, we can see the patch is properly done

CVE-2013-3403#1

- The privilege escalation to *informix* is not patched
- The patch simply does nothing about it:

```
$ ls -lah /usr/local/cm/db/ifx.txt
-rw-r--r--  1 root root 12 Feb 23... /usr/local/cm/db/ifx.txt

$ cat /usr/local/cm/db/ifx.txt
e62129826952
```

Patch

CVE-2013-3403#2

- The privilege escalation to *root* is patched
- The file cannot be overwritten by *informix* anymore
- The owner of the file was simply changed:

```
$ ls -lah /usr/local/cm/bin/cisco_creve.pl
-rwxr-x---  1 root informix.../usr/local/cm/bin/cisco_creve.pl
```

Patch

CVE-2013-3403#2

- The privilege escalation to *root* is patched
- The file cannot be overwritten by *informix* anymore
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```
$ ls -lah /usr/local/cm/bin/cisco_creve.pl
-rwxr-x---  1 root informix.../usr/local/cm/bin/cisco_creve.pl
```

Other actions

- The file *cisco_creve.pl* is also replaced by a new one
- Done in order to remove the payload left by the exploit?
- This was not done for that..

Patch

Silent patch

- Two new local *root* were also patched in the meantime
- This could be exploited using special environment variables

```
--- before/cisco_creve.pl       2013-10-05 23:48:05.722791964 +0200
+++ after/cisco_creve.pl        2013-07-02 22:07:52.000000000 +0200
@@ -129,11 +129,11 @@
...
-my $servernum = &get_servernum("$ENV{INFORMIXDIR}/etc/$ENV{ONCONFIG}");
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@@ -14,18 +14,18 @@
 sub get_servernum {
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 unless (-e $envfile) { die "Cannot find environment file: $envfile\n";}
 print "OK.\n";

-unless(-d '/tmp') { print `mkdir -p /tmp`;}
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Patch

Silent patch

- The first problem was with several environment variables
- Escape shell if the payload is a valid full path
- Read any file without permission if you win the race condition:

```
$ INFORMIXDIR='' ONCONFIG=shadow
$ while :; do sudo cisco_creve.pl & cp shadow{,.bk} && break; done
$ ls -lah shadow.bk
-r--r--r--  1 informix informix 5.1K Oct  8 13:38 shadow.bk
```

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$ ls -lah shadow.bk
-r--r--r--  1 informix informix 5.1K Oct  8 13:38 shadow.bk
```

- The second problem was with the *PATH* variable
- The first directory is owned by the *informix* user:

```
/usr/local/cm/db/informix:/usr/local/cm/db/informix/bin:/usr/local
/cm/bin:/usr/local/cm/../thirdparty/java/j2sdk/bin:/usr/kerberos/b
in:/usr/local/bin:/bin:/usr/bin:/usr/X11R6/bin:/home/sftpuser:/roo
t/.security
```

Patch

Real life

- The privilege escalation to *informix* was not patched
- Two other local *root* vulnerabilities were patched
- Preventing future exploitations can be done with a full patch

Vulnerability	Patch
Sql injection (CVE-2013-3404)	Yes
Hardcoded secret key (CVE-2013-4869)	No
Post-auth sql injection with high privileges (CVE-2013-3412)	No
Command execution (CVE-2013-3402)	No
Privilege escalation to *informix* (CVE-2013-3403#1)	No
Privilege escalation to *root* (CVE-2013-3403#2)	Yes

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Conclusion

Summary

- Cisco Unified Communications Manager Remote Root Exploit
- Does not need credentials (*pre-auth*)
- Reliable exploit with default conditions
- Exploitation using six different vulnerabilities:
  - Sql injection
  - Hardcoded secret key
  - Post-auth sql injection with high privileges
  - Command execution
  - Privilege escalation to *informix*
  - Privilege escalation to *root*

Thanks for your attention

Questions?

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