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AlexCTF 2017 write ups

Feb 06 2017

I. Introduction

I took part in the **AlexCTF**(https://ctf.oddcoder.com/) this weekend, which was an online jeopardy-style CTF. Thanks to the **Greunion**(https://ctftime.org/team/29976) team for having me!

II. CR2: Many time secrets (100 points)

This challenge is a classical OTP cryptographic challenge. We have several messages all XORed with the same key, which is the flag.
However, since we know that the flag has to follow a specific format (`ALEXCTF{[A-Za-z0-9_]*}`), we have the beginning of the key, which allows to decrypt the beginning of each message!

```
Dear Fri
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```

We can easily guess the next character for some of the messages, which in turn gives us the next character of the key. All what is left to do is repeating the process until the end of the key!
The following Python script has been used to make the process easy:

```
def xor(a, b):
    return ''.join(chr(ord(x) ^ ord(y)) for x, y in zip(a, b))

def help_find_key(msgs):
    key = 'ALEXCTF{'
    max_len = max(map(len, msgs))
    while True:
        print '\n>>', key.encode('string-escape')
        for i, msg in enumerate(msgs):
            print '%-2d' % i, xor(key, msg)
        if len(key) == max_len:
            break
        i = int(raw_input('\nline: '))
        c = raw_input('char: ')
        key += xor(msgs[i][len(key)], c)

with open('msg') as f:
    help_find_key([x.strip().decode('hex') for x in f])
```

After a few iterations, the flag is ours!

```
>> ALEXCTF{HERE_GOES_THE_KEY}
0  Dear Friend, This time I u
1  nderstood my mistake and u
2  sed One time pad encryptio
3  n scheme, I heard that it
4  is the only encryption met
5  hod that is mathematically
6   proven to be not cracked
7  ever if the key is kept se
8  cure, Let Me know if you a
9  gree with me to use this e
10 ncryption scheme always.
```

III. CR4: Poor RSA (200 points)

We have an RSA public key, and what is likely to be the flag encrypted with the corresponding private key.

```
$ openssl rsa -pubin -in key.pub -text -noout
Public-Key: (399 bit)
Modulus:
    52:a9:9e:24:9e:e7:cf:3c:0c:bf:96:3a:00:96:61:
    77:2b:c9:cd:f6:e1:e3:fb:fc:6e:44:a0:7a:5e:0f:
    89:44:57:a9:f8:1c:3a:e1:32:ac:56:83:d3:5b:28:
    ba:5c:32:42:43
Exponent: 65537 (0x10001)
```

With a key length smaller than 512 bits, it should not be too difficult to factor. Indeed, a lookup on the **factordb.com**(http://factordb.com/index.php?query=833810193564967701912362955539789451139872863794534923259743419423089229206473091408403560311191545764221310666338878019) website reveals the two factors.
All what is left is converting all parameters in a format `openssl` understands, and decrypt the flag:

```
import gmpy2

p = 863653476616376575308866344984576466644942572246900013156919
q = 965445304326998194798282228842484732438457170595999523426901
e = 65537
d = gmpy2.invert(e, (p - 1) * (q - 1))

print '''asn1=SEQUENCE:rsa_key
```

```
[rsa_key]
version=INTEGER:0
modulus=INTEGER:{n}
pubExp=INTEGER:{e}
privExp=INTEGER:{e1}
p=INTEGER:{p}
q=INTEGER:{q}
e1=INTEGER:{e1}
e2=INTEGER:{e2}
coeff=INTEGER:{coeff}'''.format(
    n=p * q,
    e=e,
    p=p,
    q=q,
    e1=d % (p - 1),
    e2=d % (q - 1),
    coeff=gmpy2.invert(q, p),
)
```

A few `openssl` commands later, we have the flag!

```
$ ./build.py > priv.conf
$ openssl asn1parse -genconf priv.conf -out priv.der -noout
$ base64 -d flag.b64 | openssl rsautl -decrypt -inkey priv.der -keyform der
ALEXCTF{SMALL_PRIMES_ARE_BAD}
```

IV. CR5: Bring weakness (300 points)

> We got this PRNG as the most secure random number generator for cryptography
> Can you prove otherwise
> nc 195.154.53.62 7412

After connecting on the server, the challenge is clear: we can generate as many random numbers in a raw as we want, and then we need to predict the next 10 numbers.

```
$ ncat 195.154.53.62 7412
Guessed 0/10
1: Guess the next number
2: Give me the next number
2
401969523
Guessed 0/10
1: Guess the next number
2: Give me the next number
2
1144833507
Guessed 0/10
1: Guess the next number
2: Give me the next number
1
Next number (in decimal) is
```

The usual issue with PRNG is due to their design: they are usually based on an internal state. Each time output is generated, the internal state is changed. Depending on the size of the internal state, the PRNG output will cycle sooner or later.

In our case, it seems that the generated numbers are 32 bits long. But that does not prove anything about the internal state, so let's ask for quite a lot of output, and analyse it:

```
$ yes 2 | ncat 195.154.53.62 7412 | grep -v ' ' | head -n 100000 > out
$ wc -l out
100000 out
$ sort -u out | wc -l
32768
```

As we can see, we have only `2^15` different outputs out of the 100000 samples we asked. A closer look reveals that the generated numbers are indeed generated in a loop, with a **full cycle**(https://en.wikipedia.org/wiki/Full_cycle) of `2^15`.

So our attack is simple:

1. Ask for 32768 consecutive outputs
2. Predict the next outputs now that we have the full cycle

This is what the following Python script does:

```
from socket import socket

class Run(object):

    def __init__(self):
        self.cycle = {}
        self.s = socket()
        self.s.connect(('195.154.53.62', 7412))
        self.buf = ''

    def Run(self):
        print '[*] Get full cycle'
        self.get_full_cycle()
        print '[*] Predict numbers'
        n = self.get_nb()
        for _ in range(11):
            n = self.cycle[n]
            self.s.sendall('1\n%d\n' % n)
        print '[*] Print flag'
        print self.recv(lambda x: 'ALEXCTF' in x)
```

```
    def recv(self, test):
        while True:
            if '\n' not in self.buf:
                self.buf += self.s.recv(1024)
                continue
            val, self.buf = self.buf.split('\n', 1)
            if test(val):
                return val

    def get_nb(self, send=True):
        if send:
            self.s.sendall('2\n')
        return int(self.recv(lambda x: all(c in '0123456789' for c in x)))

    def get_full_cycle(self):
        self.s.sendall('2\n' * 0x8001)  # sending all at once for speedup
        p = self.get_nb(False)
        for _ in range(0x8000):
            n = self.get_nb(False)
            self.cycle[p] = n
            p = n


if __name__ == '__main__':
    Run().run()
```

Running it reveals the flag as expected, and getting the full cycle took less than 3 seconds, which was a good surprise.

```
$ ./run.py
[*] Get full cycle
[*] Predict numbers
[*] Print flag
flag is ALEXCTF{f0cfad89693ec6787a75fa4e53d8bdb5}
```

V. Fore2: Mail client (100 points)

```
$ file core.1719
core.1719: ELF 64-bit LSB core file x86-64, version 1 (SYSV), SVR4-style, from 'mutt', real uid: 0, effective uid: 0, real
gid: 0, effective gid: 0, execfn: '/usr/bin/mutt', platform: 'x86_64'
```

In this challenge, we have a `mutt` coredump, and we need to extract the email and password of the user account and send them to a remote service.
We look at the strings of the coredump, and quickly find a password:

```
$ strings core.1719 | grep pass | head -3
passwd
tp_pass = "e. en kv,dvlejhgouehg;oueh fenjhqeouhfouehejbge ef"
unset imap_passive
```

This seems to be from the configuration file of mutt, but the string `tp_pass` is probably for SMTP (two first bytes missing), not IMAP.
Let's see if that password is stored somewhere else in the core dump:

```
$ strings core.1719 | fgrep 'fenjhqeouhfouehejbge' -C1
dksgkpdjg;kdj;gkje;gj;dkgv a enpginewognvln owkge  noejne
e. en kv,dvlejhgouehg;oueh fenjhqeouhfouehejbge ef
gpg --no-verbose --export --armor %r
--
172.17.0.2  78932fb3f2a0
tp_pass = "e. en kv,dvlejhgouehg;oueh fenjhqeouhfouehejbge ef"
set from = "alexctf@example.com"
```

So we have the email address, and also an other line just before the SMTP password… maybe it is the IMAP password?

```
$ ncat 195.154.53.62 2222
Email: alexctf@example.com
Password: dksgkpdjg;kdj;gkje;gj;dkgv a enpginewognvln owkge  noejne
1 new unread flag
ALEXCTF{Mu77_Th3_CoRe}
```

We were lucky this time!

VI. RE2: C++ is awesome (100 points)

This is a classical crackme: the `re2` binary is taking a flag as the first parameter, and tels us if the flag is valid or not.
I remember reading **an article from Jonathan Salwan**(http://shell-storm.org/blog/A-binary-analysis-count-me-if-you-can/) , where he uses **Intel PIN**(https://software.intel.com/en-us/articles/pin-a-dynamic-binary-instrumentation-tool) to bruteforce a flag one character at a time.
Indeed, if the program checks the flag character by character, we can try all possible values for the first character. The good one will be the one for which the more CPU instructions have been run.
I edited his Python code to the following:

```
import commands

charset = 'abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789_'

def count(flag):
    cmd = "./pin -t source/tools/ManualExamples/obj-intel64/inscount0.so" \
          " -- ./re2 ALEXCTF{%s} > /dev/null; cat inscount.out" % flag
    res = int(commands.getstatusoutput(cmd)[1].split("Count")[1])
    print res, flag
    return res
```

```
flag = ''
while True:
    best_t = last_t = count(flag)
    best_c = ''
    for c in charset:
        t = count(flag + c)
        if t > best_t:
            best_t = t
            best_c = c
    print
    if best_t == last_t:
        print 'FOUND: ALEXCTF{%s}' % flag
        break
    flag += best_c
```

And run it: it just worked under 10 minutes!

```
$ time ./run.py
2053431
2053431 a
2053431 b

--<snip>--

FOUND: ALEXCTF{W3_L0v3_C_W1th_CL45535}

real    9m59.075s
user    8m18.984s
sys     1m28.124s
```

VII. RE4: unVM me (250 points)

This challenge starts with a compiled Python code.

```
$ file unvm_me.pyc
unvm_me.pyc: python 2.7 byte-compiled
```

We use the corresponding **uncompyle**(https://github.com/rocky/python-uncompyle6) version and retrieve the following Python code.

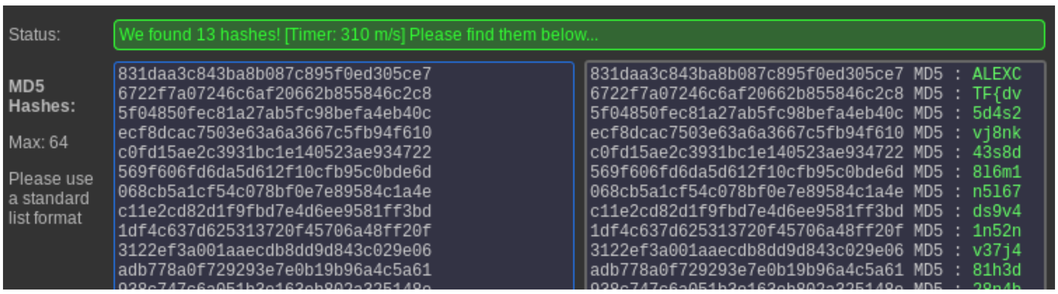
```
import md5
md5s = [174282896860968005525213562254350376167L,
 137092044126081477479435678296496849608L,
 126300127609096051658061491018211963916L,
 314989972419727999226545215739316729360L,
 256525866025901597224592941642385934114L,
 115141138810151571209618282728408211053L,
 8705973470942652577929336993839061582L,
 256697681645515528548061291580728800189L,
 39818552652170274340851144295913091599L,
 65313561977812018046200997898904313350L,
 230909080238053318105407334248228870753L,
 196125799557195268866757688147870815374L,
 74874145132345503095307276614727915885L]
print 'Can you turn me back to python ? ...'
flag = raw_input('well as you wish.. what is the flag: ')
if len(flag) > 69:
    print 'nice try'
    exit()
if len(flag) % 5 != 0:
    print 'nice try'
    exit()
for i in range(0, len(flag), 5):
    s = flag[i:i + 5]
    if int('0x' + md5.new(s).hexdigest(), 16) != md5s[i / 5]:
        print 'nice try'
        exit()

print 'Congratz now you have the flag'
```

So the flag is cut in 13 parts of 5 characters, and we have the md5 hash of each part. Of course, we like the md5 hashes better in hex format, so let's convert them with some Python:

```
for m in md5s:
    print '%032x' % m
```

Then, we could use **John the Ripper**(http://www.openwall.com/john/) , but since the plaintexts are only 5 characters long, rainbow tables are the way to go!
Or, if we are lazy, just ask an online service like **hashkiller**(https://hashkiller.co.uk/md5-decrypter.aspx) :



This gives us the flag: `ALEXCTF{dv5d4s2vj8nk43s8d8l6m1n5l67ds9v41n52nv37j481h3d28n4b6v3k}`.

VIII. Conclusion

This is the end of the AlexCTF challenge, which was long enough! 48 hours CTFs are quite a time investment. Nothing is like trying to extract a flag from a lolcat at 10:30pm (that was our last flag to score)…

At the end, **we**(https://ctftime.org/team/29976) solved every single challenge and ranked 7 out of 1000+ participants!

Place	Team	Score
1	p4	2540
2	dcua	2540
3	CodiSec	2540
4	DlcsHrs	2540
5	Snatch The Root	2540
6	c00kies@venice	2540
7	greunion	2540
8	POWERHACKER	2540
9	ffffx00000	2540
10	0x00C0FFEE	2540

Short URL: **http://r.rogdham.net/28**.