Visiting The Bear Den

A Journey in the Land of (Cyber-)Espionage

Joan Calvet

Jessy Campos

Thomas Dupuy

Sednit Group

- Also know as APT28, Fancy Bear, Sofacy, STRONTIUM, Tsar Team
- Group of attackers doing targeted attacks since 2006
- Mainly interested into geopolitics

Plan

- Context
- The Week Serge Met The Bear
- The Mysterious DOWNDELPH
- Speculative Mumblings

What kind of group is Sednit?

CONTEXT

Who Is The Bear After? (1)

- We found a list of targets for Sednit phishing campaigns:
  - Operators used *Bitly* and “forgot” to set the profile private

    (feature now removed from Bitly)

  - Around 4,000 shortened URLs during 6 months in 2015

Who Is The Bear After? (2)

http://login.accoounts-google.com/url/?continue=cGFyZXBreWl2QGdtYWlsLmNvbQ==&df=UGFraXN0YW4rRW1iYXNzeStLeWl2&tel=1

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parepkyiv@gmail.com

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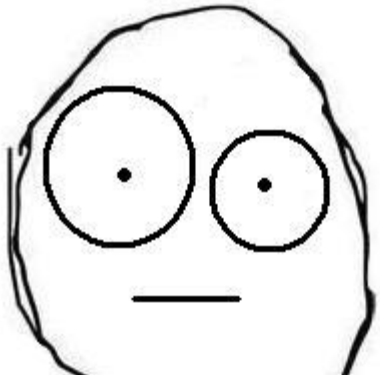
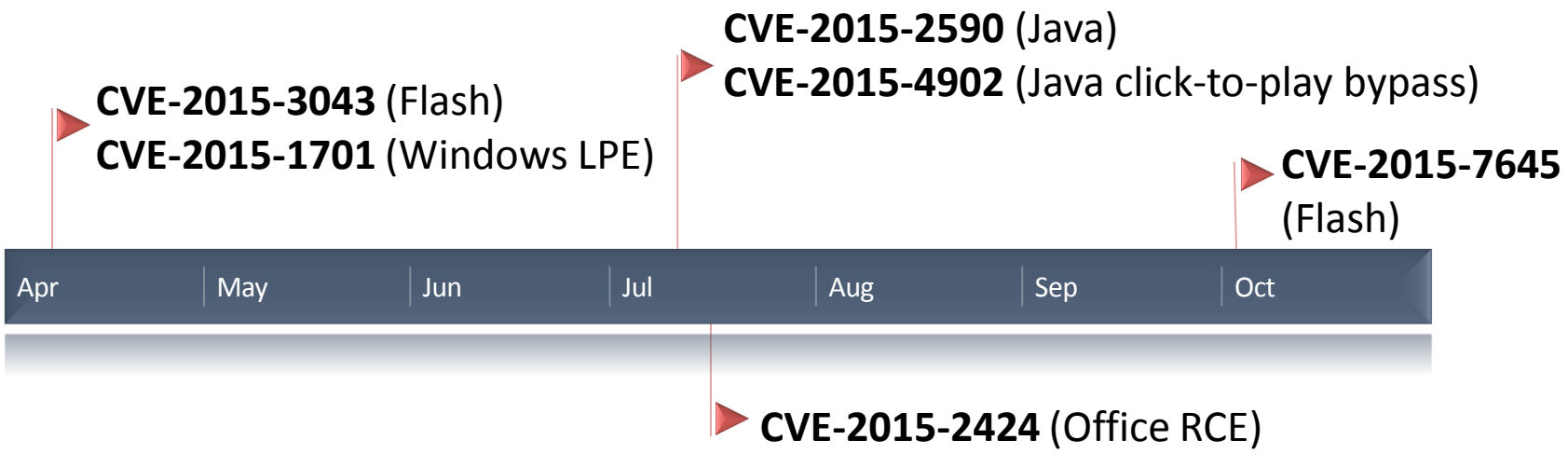


Who Is The Bear After? (3)

- Embassies and ministries of more than 40 countries
- NATO and EU institutions
- "Who's who" of individuals involved in Eastern Europe politics:
  - Politicians
  - Activists
  - Journalists
  - Academics
  - Militaries
  - …

The Bear Has Money

- A bag full of 0-day exploits:



2015

The Bear Can Code

- Tens of custom-made software used since 2006:
  - Droppers
  - Downloaders
  - Reconnaissance tools
  - Long-term spying backdoors
  - Encryption proxy tool
  - USB C&C channel
  - Many helper tools
  - …

Disclaimers

- Over the last two years we tracked Sednit closely, but of course **our visibility is not exhaustive**

- How do we know it is ONE group?
  - We don't
  - Our Sednit "definition" is based on their toolkit and the related infrastructure

- We do not do attribution (but we point out hints that *may* be used for that)

THE WEEK SERGE MET THE BEAR

Who Is Serge?

- Code name for an imaginary Sednit target
- Serge is a government employee with access to sensitive information
- The chain of events in Serge's attack matches several real cases we investigated
- We use it as a textbook case to present (*a part of*) the Sednit toolkit

MONDAY, 9:30AM

Serge Opens an Email

From noreply@stratfor.com
Subject **Geopolitical Weekly**
To Claude

Dear Sir,
Please read this report by Sratfor Global Intelligence:
http://stratforglobal.net/weekly/51586/ruthless-and-sober-syria
Kind regards,

Stratfor Global Intelligence

P.O. Box 92529
Austin, Texas 78709-2529
USA
T +1 512 744 4300
F +1 512 744 4334

Legitimate URL Mimicking

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Serge clicks on the URL, and…

…Serge Meets SEDKIT

- Exploit-kit for targeted attacks
- Entry-point URLs mimic legitimate URLs
- Usually propagated by targeted phishing emails (also seen with hacked website + iframe)
- Period of activity: September 2014 - Now

Landing Page (1)

Reconnaissance Report Building

```
string_of_json += "\"timezone\"" + ":" + getTimeZone() + ",";

for(var prop in navigator) {
    string_of_json += ...[REDACTED]...
}

string_of_json += "\"screen\":{ ";
for(var prop in screen) {
    string_of_json += ...[REDACTED]...
}

string_of_json += "\"plugins\":[ ";
//string_of_json += DetectJavaForMSIE();
if(navigator.userAgent.indexOf("MSIE") > -1 ||
    navigator.userAgent.indexOf("Trident\/7.0") > -1)
{
    string_of_json += DetectJavaForMSIE();
    string_of_json += DetectFlashForMSIE();
    string_of_json += EnumeratePlugins();
    //string_of_json += DetectPdfForMSIE();
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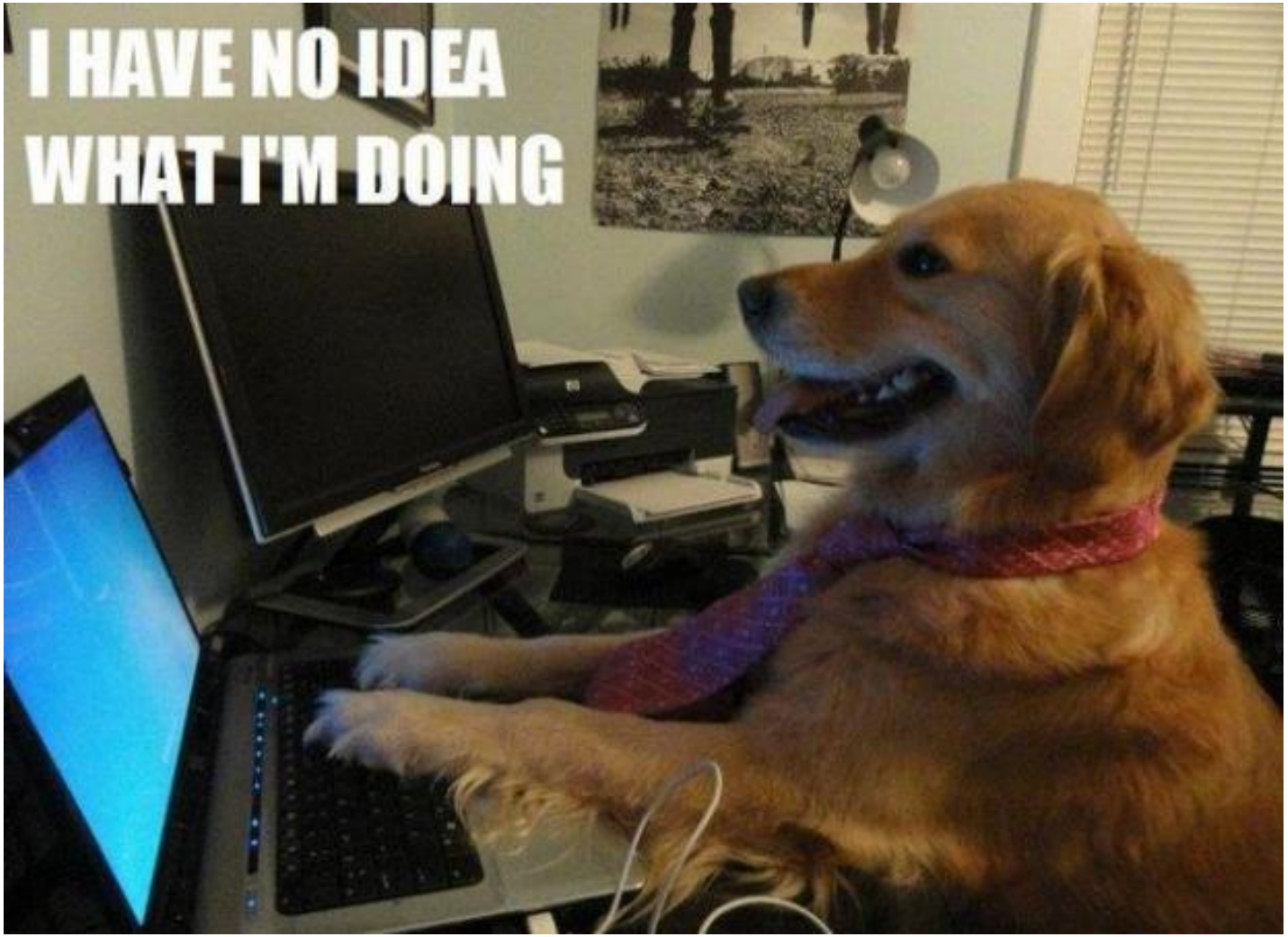
```
"timezone": 420,

"appCodeName": "Mozilla",
"appName": "Microsoft Internet Explorer",
"appMinorVersion": "0",
"cpuClass": "x86",
"platform": "Win32",
"systemLanguage": "en-us",
"userLanguage": "en-us",
"appVersion": "4.0 (compatible; MSIE 8.0; Windows NT 6
"userAgent": "Mozilla/4.0 (compatible; MSIE 8.0; Windo
"onLine": true,
"cookieEnabled": true,
"mimeTypes": "",

"screen": {
  "height": 1080,
  "bufferDepth": 0,
  "deviceXDPI": 96,
  "...[REDACTED]..."
  "colorDepth": 32,
  "width": 1920,
  "availWidth": 1920,
  "updateInterval": 0
},

"plugins": [
  {"name": "Java","version": "1.6.0"},
  {"name": "ShockwaveFlash","version": "11.8.800.94"}
]
```

Crawling Sedkit



Serge is selected to be exploited…

… and Visits Sednit Exploits Factory

Vulnerability	Targeted Application	Note
CVE-2013-1347	Internet Explorer 8	
CVE-2013-3897	Internet Explorer 8	
CVE-2014-1510 + CVE-2014-1511	Firefox	
CVE-2014-1776	Internet Explorer 11	
CVE-2014-6332	Internet Explorer	Several versions
N/A	MacKeeper	
CVE-2015-2590 + CVE-2015-4902	Java	0-day*
CVE-2015-3043	Adobe Flash	0-day*
CVE-2015-5119	Adobe Flash	Hacking Team gift
CVE-2015-7645	Adobe Flash	0-day*

** : At the time SEDKIT dropped them*

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Revamping CVE-2014-6332
(a.k.a. IE “Unicorn bug”)

- October 2015:
  - Re-use of public PoC to disable VBScript “SafeMode”
  - Next stage binary downloaded by PowerShell

Revamping CVE-2014-6332
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- October 2015:
  - Re-use of public PoC to disable VBScript “SafeMode”
  - Next stage binary downloaded by PowerShell

- February 2016:
  - No more “SafeMode” disabling, direct ROP-based shellcode execution
  - Around 400 lines of VBScript, mostly custom

```
function createROP()
    On Error Resume Next

    shell_string = Unescape("%u8b64%u002d%u0000%u8b00...

[...REDACTED...]

    ie_11_case(ole32_base)
    addToROP(ie_11_case_addr)
    addToROP(rop_case_addr)
    addToROP(&h04040404)
    addToROP(vp_address)
    addToROP(&h04040404)
    addToROP(shell_addr)
    addToROP(shell_addr)
    addToROP(&h1000)
    addToROP(&h40)
    addToROP(shell_addr+1000)
    ab(3) = rop_string
end function
```

```
function Code_section_explorer_7( Libb_base_addr)

    dim Lib_PE_offset,Number_of_section,Section_table_addr,RVA_section_table,
        Lib_PE_addr,code_section_addr,code_section_length,choice
    Lib_PE_offset = readM(Libb_base_addr + &h3c)
    Lib_PE_addr = Libb_base_addr + Lib_PE_offset
    Number_of_section = readM(Lib_PE_addr+6)
    Number_of_section = Number_of_section  mod 65536
    if Number_of_section < 0 then Number_of_section = Number_of_section + 65536
    RVA_section_table = readM(Lib_PE_addr+20)
    RVA_section_table = RVA_section_table mod 65536
    if RVA_section_table < 0 then RVA_section_table = RVA_section_table + 65536
    Section_table_addr = Lib_PE_addr + 24 + RVA_section_table
    for i=0 to Number_of_section
        if(readM(Section_table_addr) <> 2019914798) then Section_table_addr =
            Section_table_addr + 40
    Next
    code_section_length = readM(Section_table_addr+8)
    code_section_addr = readM(Section_table_addr+12) + Libb_base_addr

    for i=code_section_addr to code_section_addr+code_section_length
        if(readM(i) = &h50895c50) then
            if(readM(i+4) = &h54508964) then
                if(readM(i+8) = &h89745089) then
                    if(readM(i+12) = &h5d5e6850) then
                        rop_case_addr = i
```

VBScript Framework

- Functions:
  - addToROP()
  - getROPstringAddress ()
  - Code_section_explorer_7 ()
  - Code_section_explorer_XP()
  - getNeddedAddresses ()
  - addrToHex ()
  - …

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  - …

Have you ever seen this somewhere?

(cuz we don't)

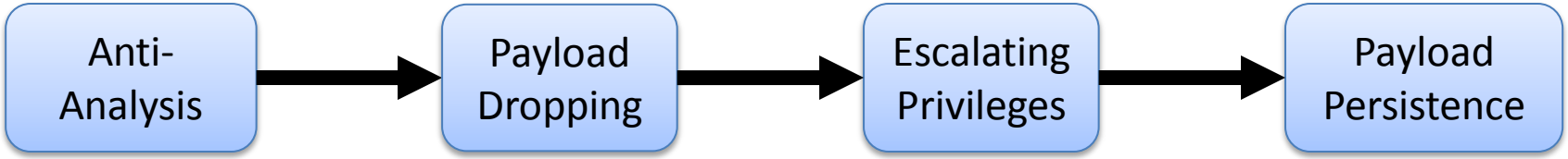
Exploit downloads a payload and…

Serge Meets SEDUPLOADER
(a.k.a. JHUHUGIT, JKEYSKW)

- Downloaded by SEDKIT
- Two binaries: the dropper and its embedded payload
- Deployed as a first-stage component
- Period of activity: March 2015 - Now

SEDUPLOADER DROPPER

Workflow



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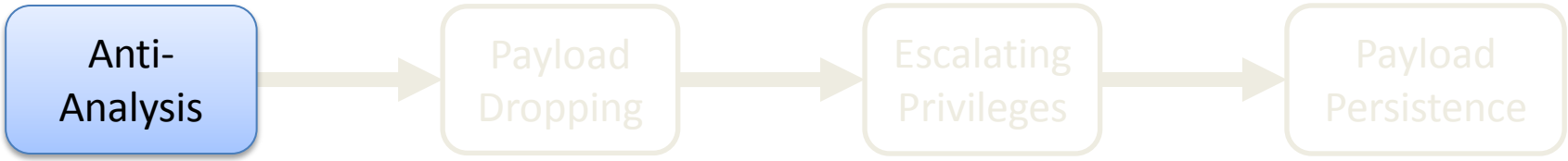

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v5 = (malloc)(0xAi64);
v6 = v5;
if ( v5 )
{
  *(v5 + 9) = 42;
  GetTempPathA(0x104u, &Buffer);
  v7 = (strncat)(&Buffer, "jhuhugit.temp", &Count);
  v8 = CreateFileA(v7, 0xC0000000, 3u, 0i64, 1u, 0x80u, 0i64);
  if ( v8 )
  {
    v9 = 1000000i64;
    v10 = 1000000i64;
    do
    {
      WriteFile(v8, v6, 7u, NumberOfBytesWritten, 0i64);
      --v10;
    }
    while ( v10 );
    CloseHandle(v8);
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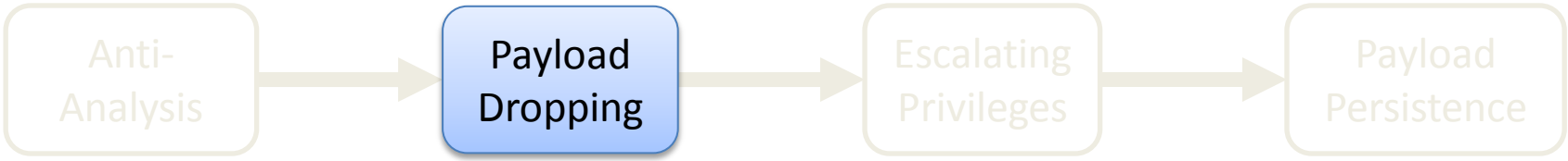
SEDUPLOADER DROPPER

Workflow




```
;
; class UpLoader: IUpLoader;  [SI] O: 0, A: 0  (Class Informer)
                dd offset ??_R4UpLoader@@6B@
; const UpLoader::`vftable'
??_7UpLoader@@6B@
                dd offset m_decrypt_in_place
                dd offset m_decrypt_in_memory
                dd offset m_get_env_variable
                dd offset m_decrypt_embedded_files
                dd offset m_decompress
                dd offset m_write_file
                dd offset m_execute_file
                dd offset m_delete_file
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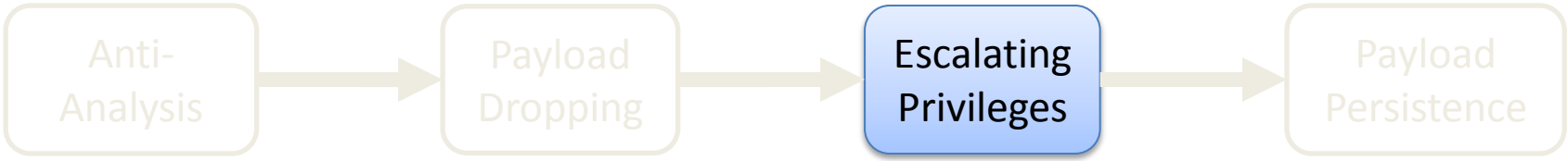

- CVE-2015-1701 (0-day)
- CVE-2015-2387 (]⊢T[ )

SEDUPLOADER DROPPER

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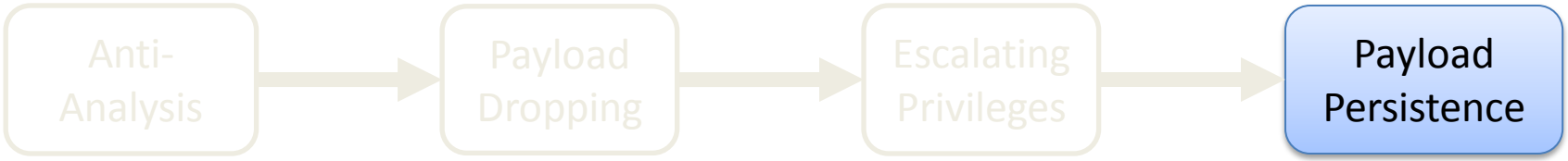

- Windows COM object hijacking
- Shell Icon Overlay COM object
- Registry key *UserInitMprLogonScript*
- JavaScript code executed within rundll32.exe
- Scheduled tasks, Windows service,…

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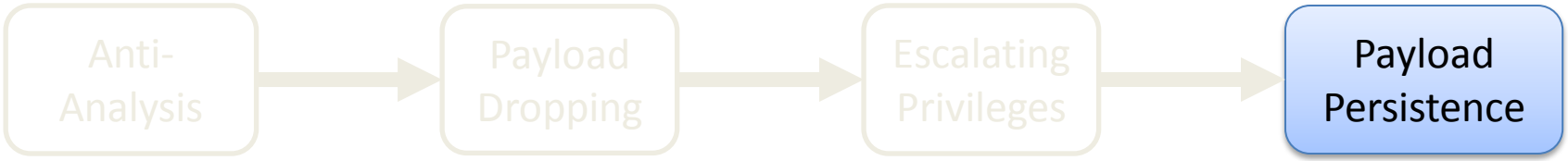

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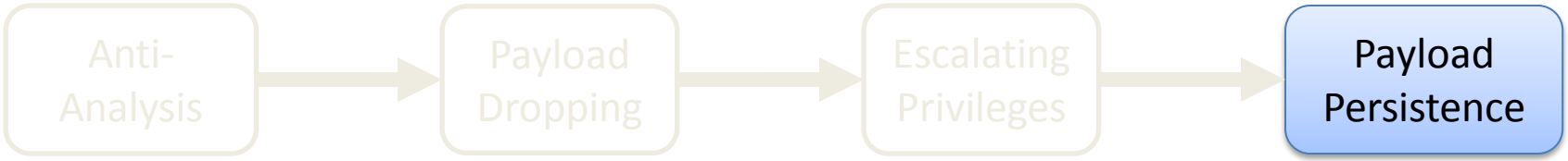


- Windows COM object hijacking Win32/COMpfun
- Shell Icon Overlay COM object
- Registry key *UserInitMprLogonScript*
- JavaScript code executed within rundll32.exe Win32/Poweliks
- Scheduled tasks, Windows service,…

SEDUPLOADER PAYLOAD

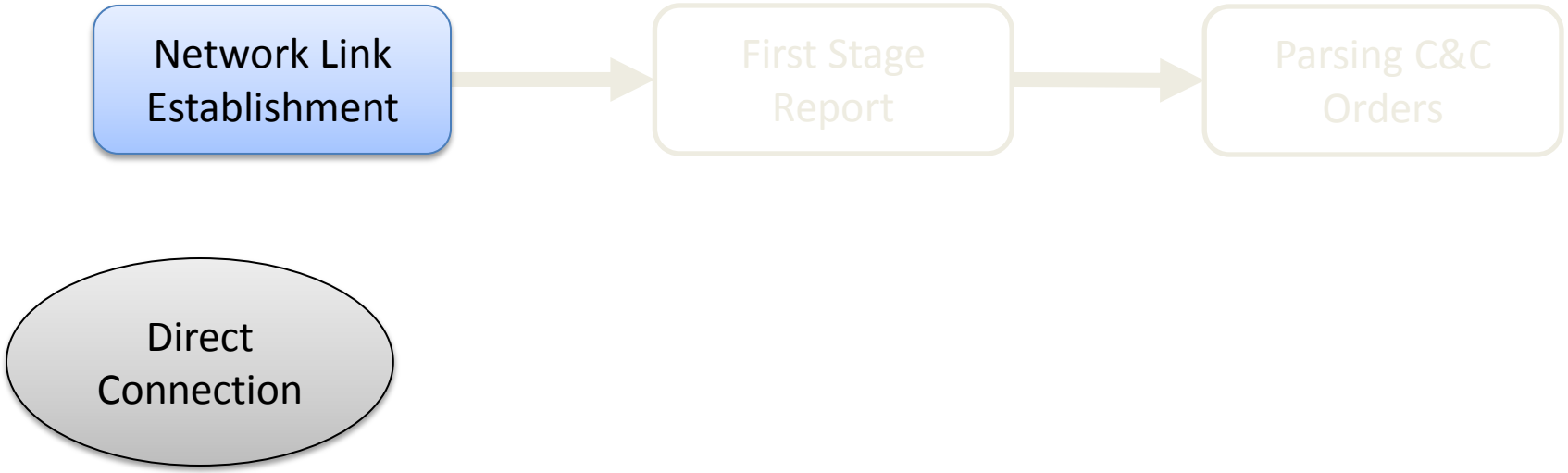
Workflow

SEDUPLOADER PAYLOAD

Workflow

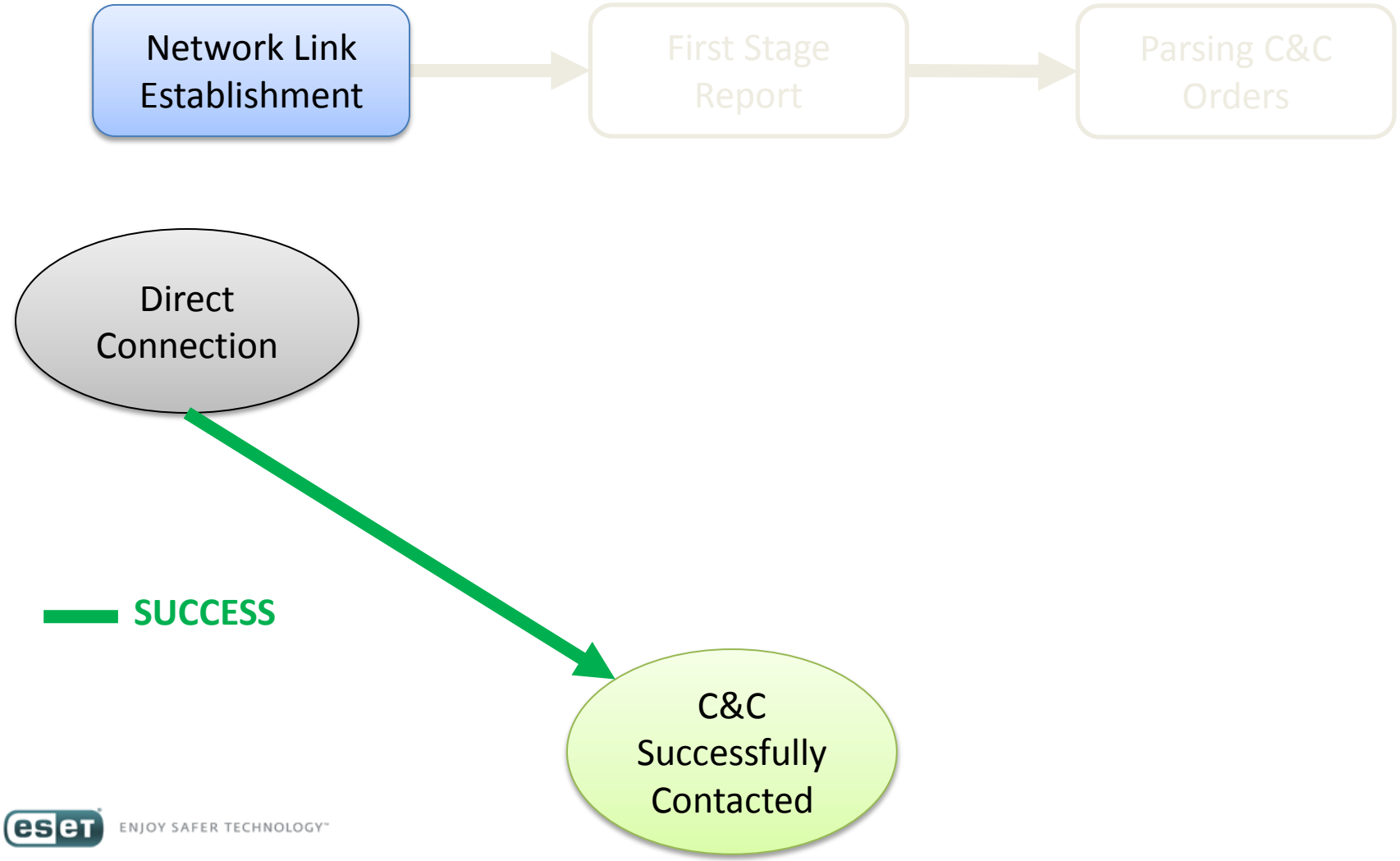
SEDUPLOADER PAYLOAD

Workflow



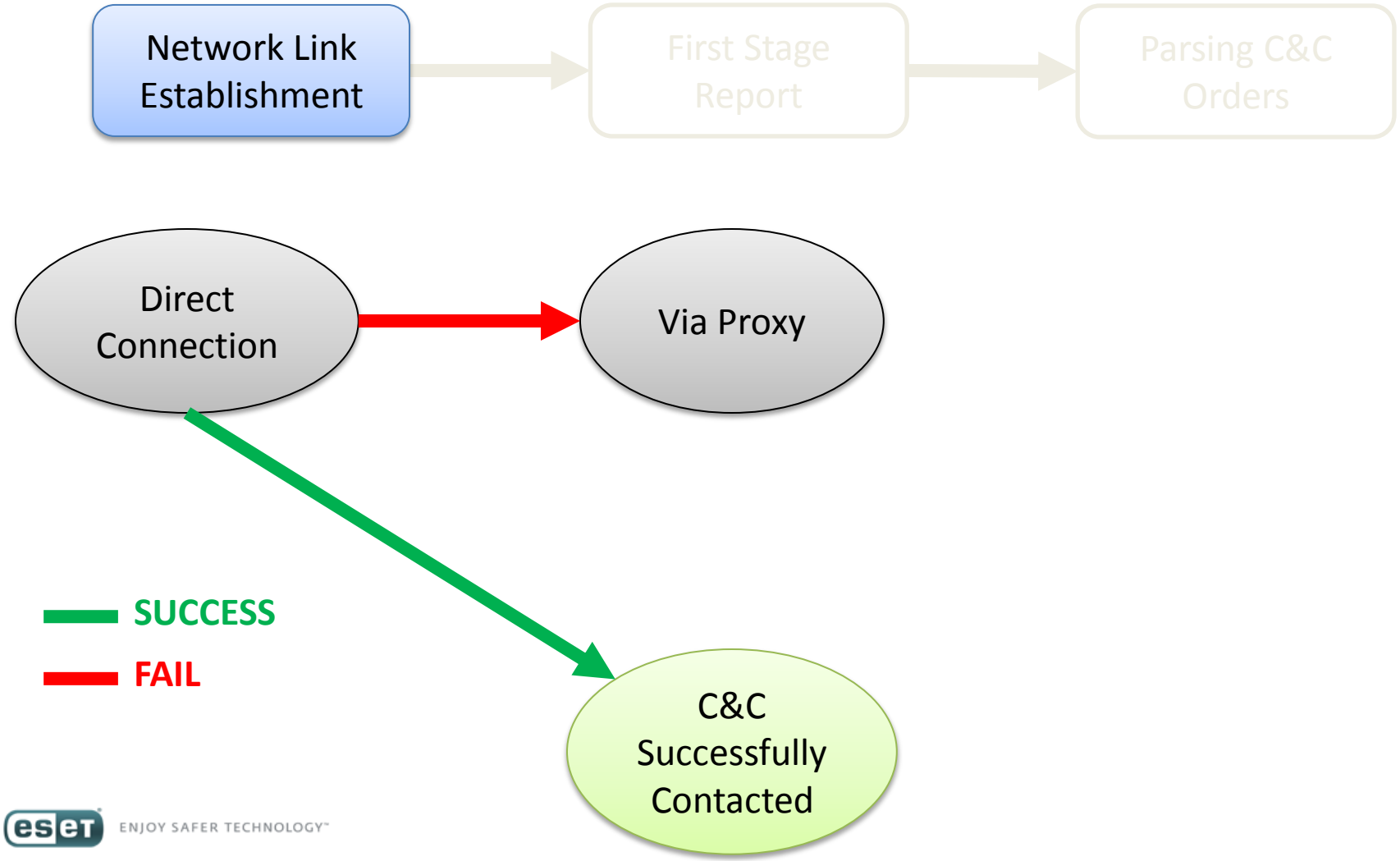
SEDUPLOADER PAYLOAD

Workflow



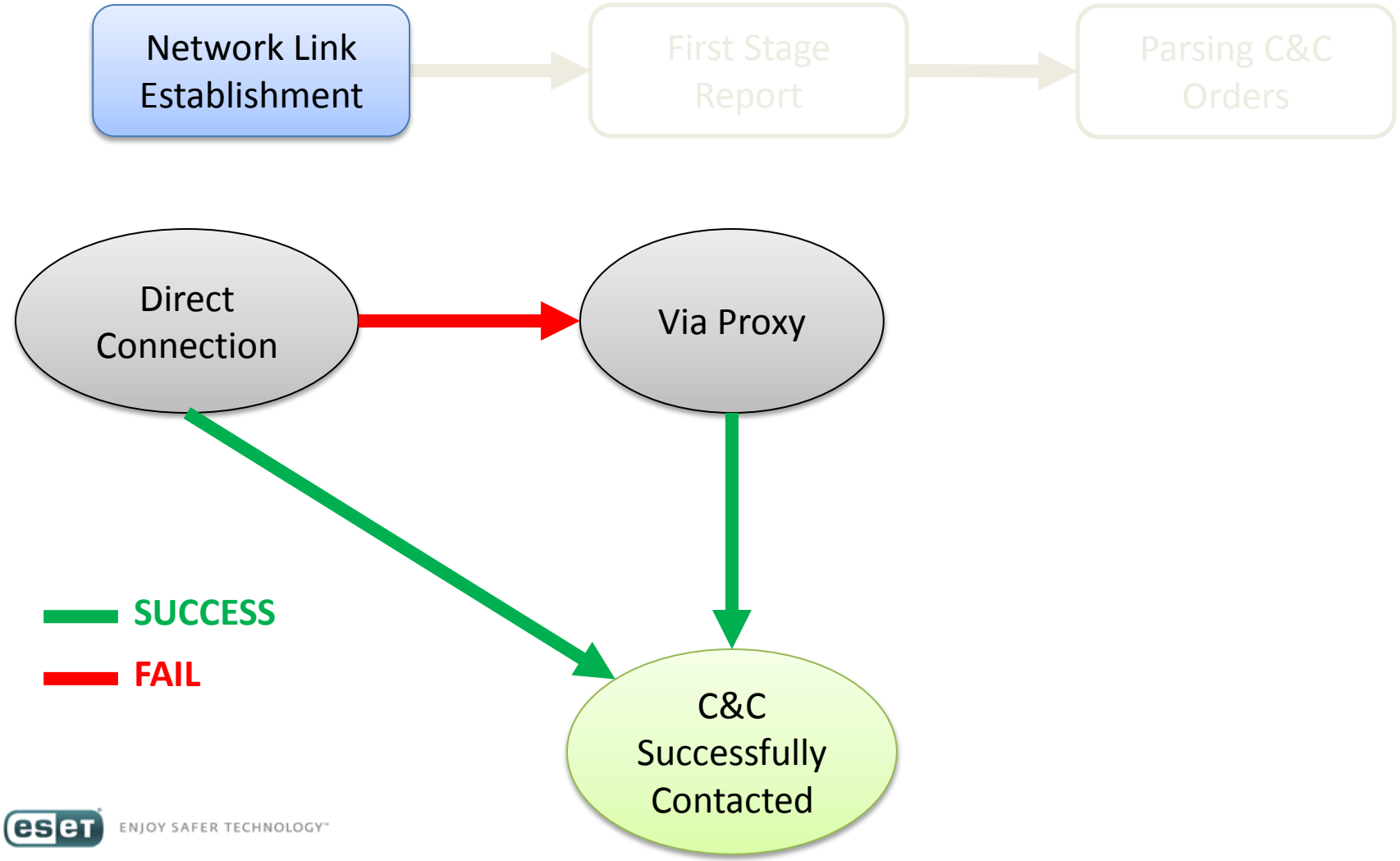
SEDUPLOADER PAYLOAD

Workflow



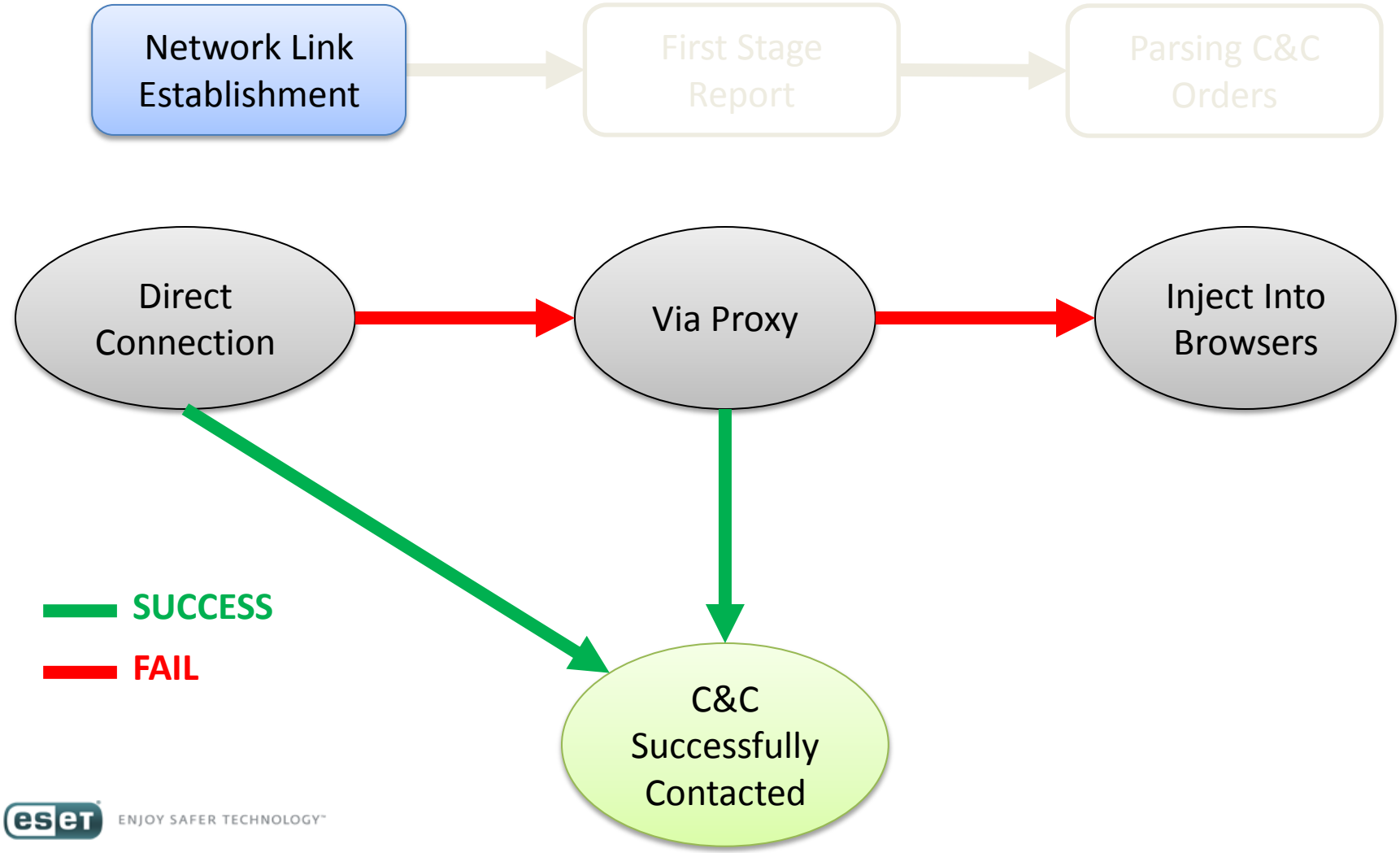
SEDUPLOADER PAYLOAD

Workflow



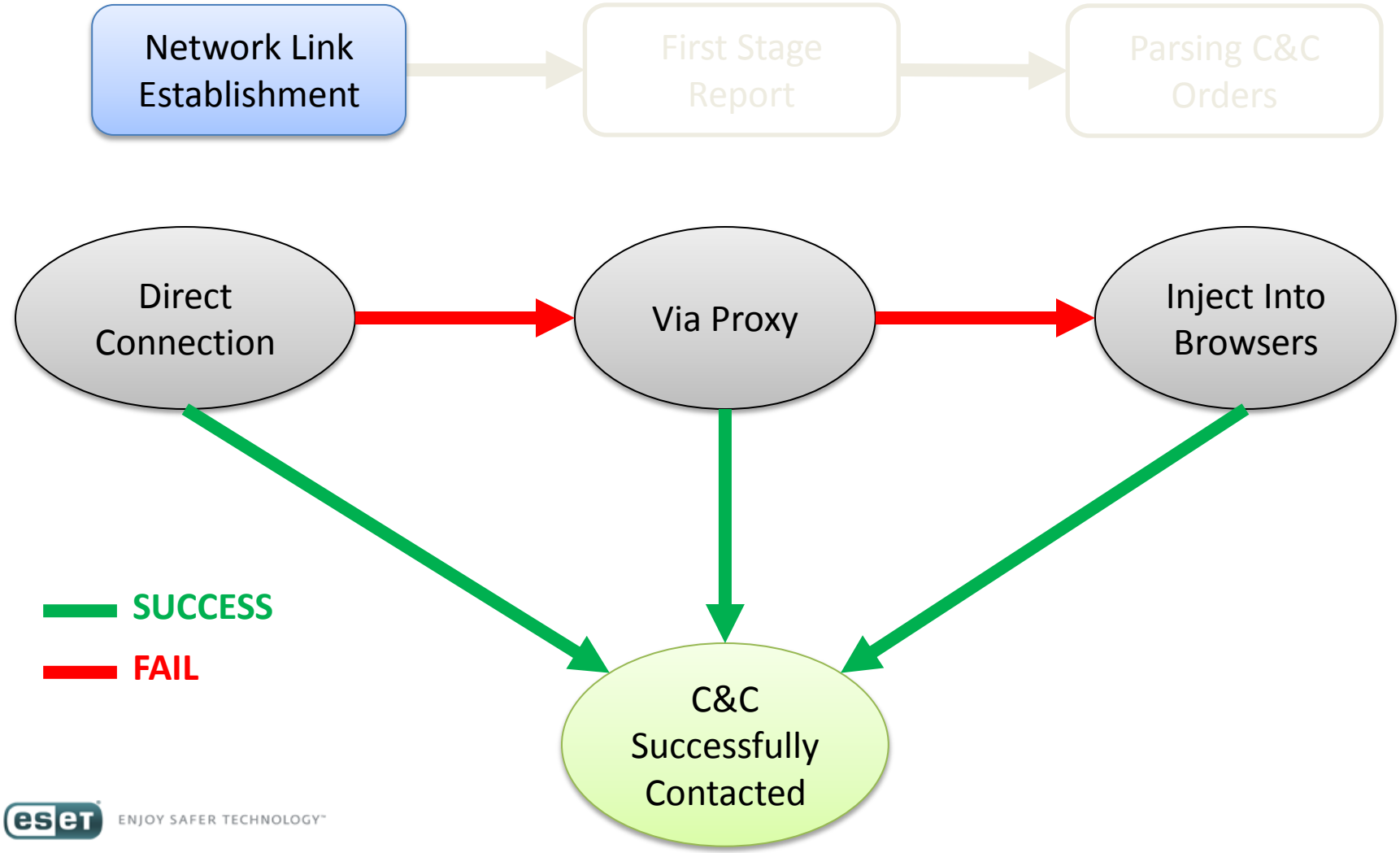
SEDUPLOADER PAYLOAD

Workflow



SEDUPLOADER PAYLOAD

Workflow



SEDUPLOADER PAYLOAD

Workflow


```
id=ÔÄ;ò&w=@[System Process]
System
smss.exe
csrss.exe
...
[REDACTED]
...
disk=SCSI\Disk&Ven_VMware_&Prod_VMware_Virtual_S\....
build=0xb58f978f
```

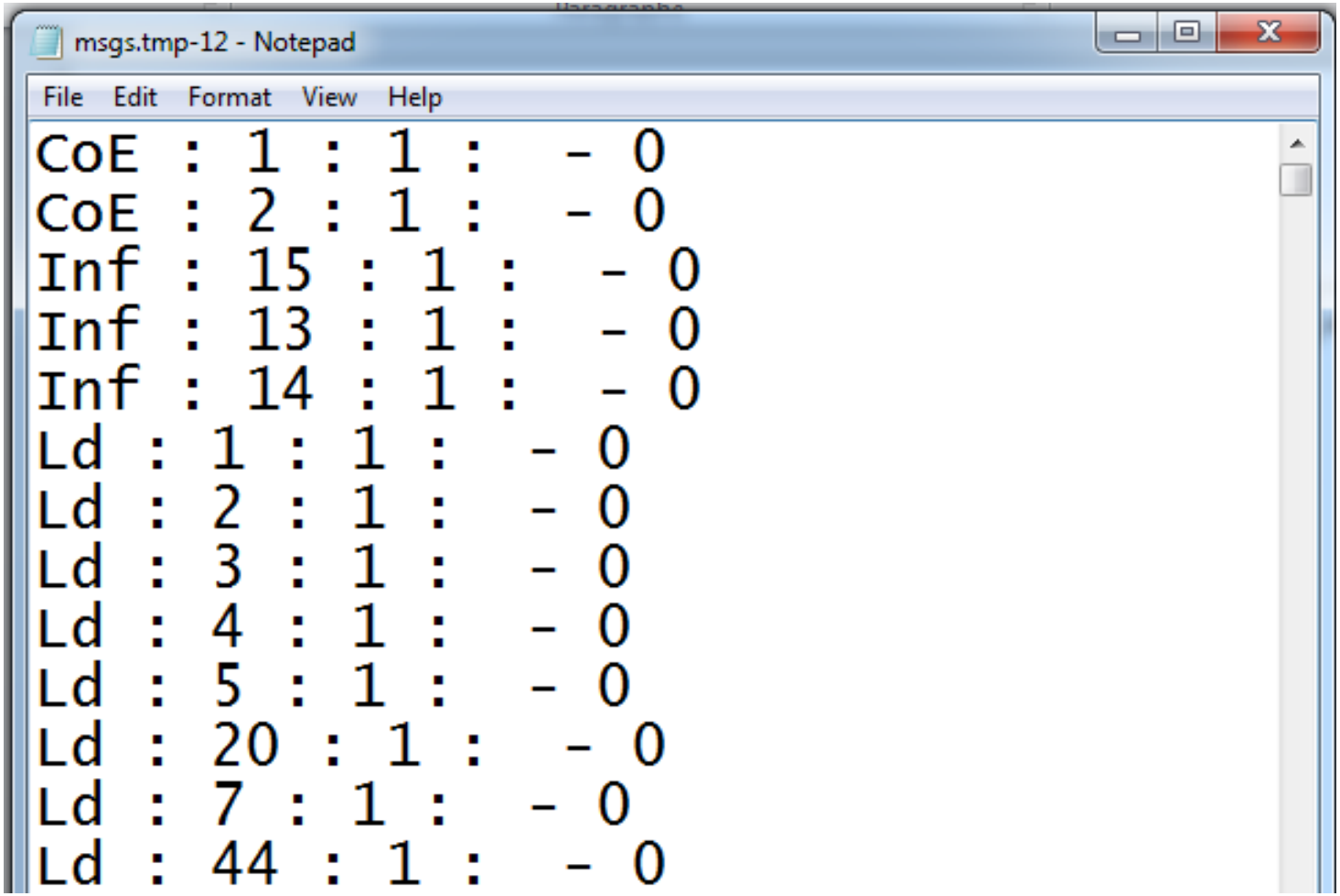
SEDUPLOADER PAYLOAD

Workflow


```
[file]
Execute
Delete
[settings]
Rundll=<export>
PathToSave=
FileName=
IP=
[/settings]
[/file]
```

East Side Story

printf debugging



Chain of Events

Serge opens an email leading to SEDKIT, and then SEDUPLOADER

9:30AM


MONDAY, 10:00AM

…Serge meets SEDRECO

- Downloaded by SEDUPLOADER
- Backdoor with the ability to load external plugins
- Usually deployed as a second stage backdoor to spy on the infected computer
- Period of activity : 2012 - Now

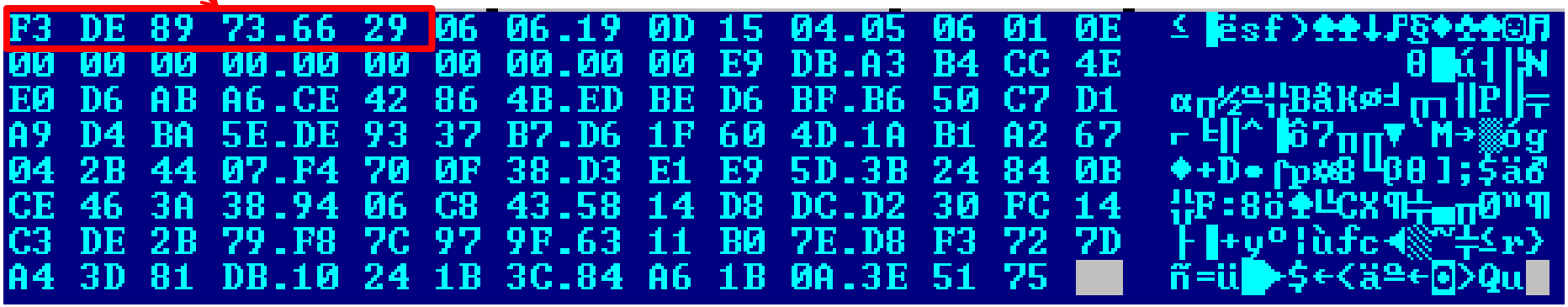
Dropper

- Drops encrypted configuration
  - In a file (“msd”)
  - In the Windows Registry
- No configuration linked to the payload

Configuration Overview

Configuration Overview

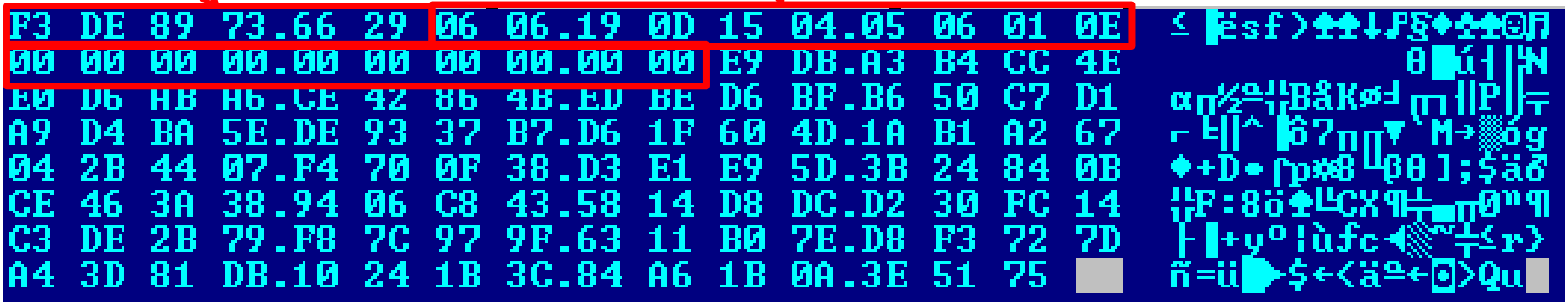
XOR KEY



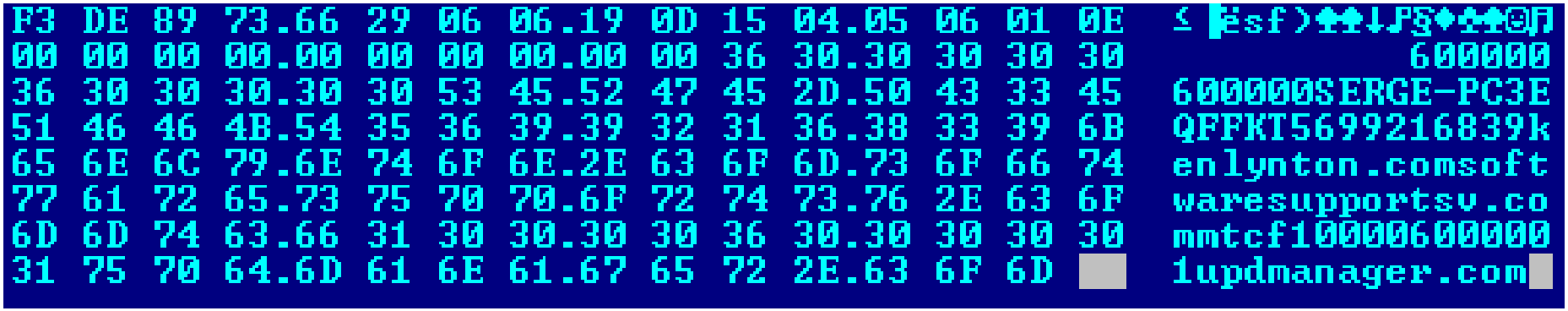
Configuration Overview

XOR KEY

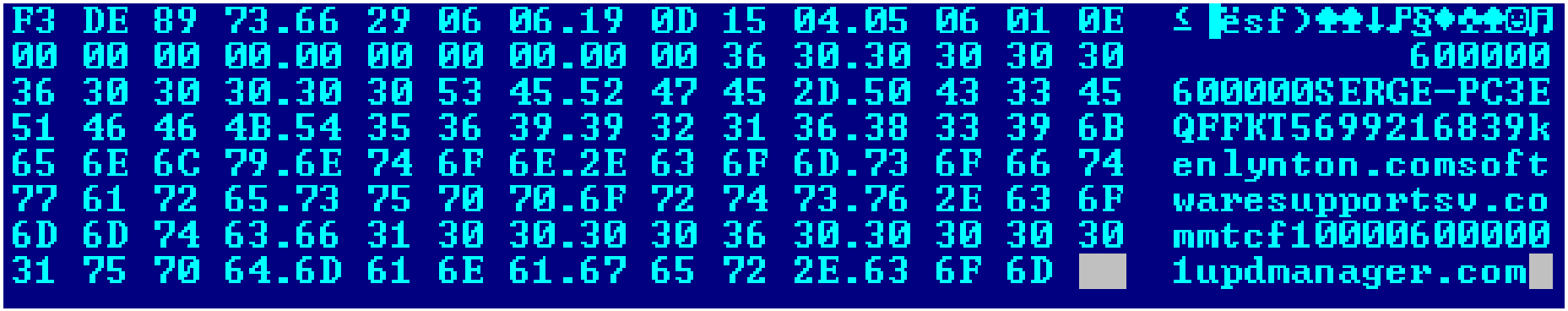
FIELD SIZES

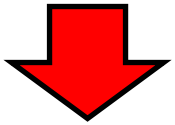


Configuration Overview (Decrypted)



Configuration Overview (Decrypted)





```
('600000', '600000', ‘SERGE-PC…', 'kenlynton.com',
'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
 'updmanager.com', '', '', '', '', '', '', '', '', '', '')
```

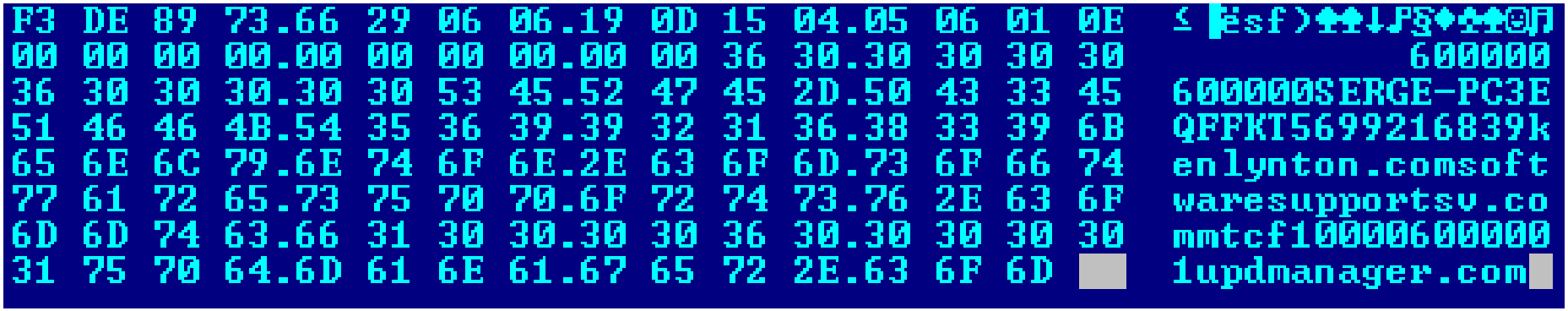
Configuration Overview (Decrypted)

```
F3 DE 89 73.66 29 06 06.19 0D 15 04.05 06 01 0E   ≤ ╔sf)♠♠↓♪§♦♣♠◙♫
00 00 00 00.00 00 00 00.00 00 36 30.30 30 30 30                 600000
36 30 30 30.30 30 53 45.52 47 45 2D.50 43 33 45   600000SERGE-PC3E
51 46 46 4B.54 35 36 39.39 32 31 36.38 33 39 6B   QFFKT5699216839k
65 6E 6C 79.6E 74 6F 6E.2E 63 6F 6D.73 6F 66 74   enlynton.comsoft
77 61 72 65.73 75 70 70.6F 72 74 73.76 2E 63 6F   waresupportsv.co
6D 6D 74 63.66 31 30 30.30 30 36 30.30 30 30 30   mmtcf1000060000
31 75 70 64.6D 61 6E 61.67 65 72 2E.63 6F 6D      1updmanager.com
```

Various timeouts

```
('600000', '600000', 'SERGE-PC…', 'kenlynton.com',
'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
 'updmanager.com', '', '', '', '', '', '', '', '', '', '')
```

Configuration Overview (Decrypted)



Computer name

```
('600000', '600000', 'SERGE-PC…', 'kenlynton.com',
'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
 'updmanager.com', '', '', '', '', '', '', '', '', '', '')
```

Configuration Overview (Decrypted)

```
F3 DE 89 73.66 29 06 06.19 0D 15 04.05 06 01 0E   ≤ ▌ésf)♠♠↓♪§♦♠♠☺♬
00 00 00 00.00 00 00 00.00 00 36 30.30 30 30 30             600000
36 30 30 30.30 30 53 45.52 47 45 2D.50 43 33 45   600000SERGE-PC3E
51 46 46 4B.54 35 36 39.39 32 31 36.38 33 39 6B   QFFKT5699216839k
65 6E 6C 79.6E 74 6F 6E.2E 63 6F 6D.73 6F 66 74   enlynton.comsoft
77 61 72 65.73 75 70 70.6F 72 74 73.76 2E 63 6F   waresupportsv.co
6D 6D 74 63.66 31 30 30.30 30 36 30.30 30 30 30   mmtcf10000600000
31 75 70 64.6D 61 6E 61.67 65 72 2E.63 6F 6D      1updmanager.com
```

Keylogger enabled

('600000', '600000', ‘SERGE-PC…', 'kenlynton.com',
'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
'updmanager.com', '', '', '', '', '', '', '', '', '', '')

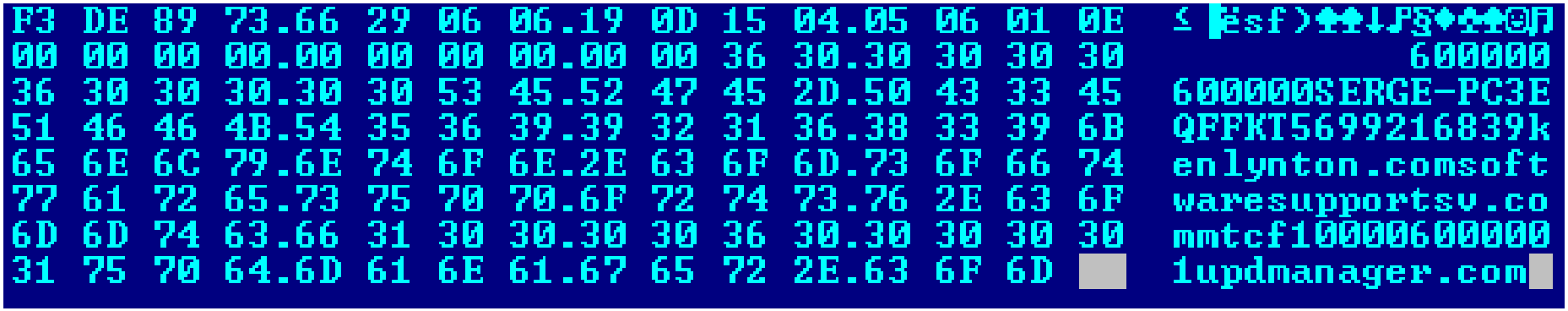
Configuration Overview (Decrypted)

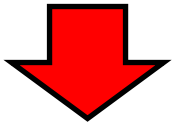
```
F3 DE 89 73.66 29 06 06.19 0D 15 04.05 06 01 0E   ≤ éšf)♠♠↓ƒ§♦♠♠☺ƒ
00 00 00 00.00 00 00 00.00 00 36 30.30 30 30 30             600000
36 30 30 30.30 30 53 45.52 47 45 2D.50 43 33 45   600000SERGE-PC3E
51 46 46 4B.54 35 36 39.39 32 31 36.38 33 39 6B   QFFKT569921683 9k
65 6E 6C 79.6E 74 6F 6E.2E 63 6F 6D.73 6F 66 74   enlynton.comsoft
77 61 72 65.73 75 70 70.6F 72 74 73.76 2E 63 6F   waresupportsv.co
6D 6D 74 63.66 31 30 30.30 30 36 30.30 30 30 30   mmtcf10000600000
31 75 70 64.6D 61 6E 61.67 65 72 2E.63 6F 6D      1updmanager.com
```

```
('600000', '600000', ‘SERGE-PC…', 'kenlynton.com',
'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
'updmanager.com', '', '', '', '', '', '', '', '', '', '')
```

C&C servers

Configuration Overview (Decrypted)





```
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'softwaresupportsv.com', 'mtcf', '10000', '600000', '1',
 'updmanager.com', '', '', '', '', '', '', '', '', '', '')
```

Operation name
(rhst, rhbp, mctf, mtqs)

Configuration Overview (Decrypted)

```
F3 DE 89 73.66 29 06 06.19 0D 15 04.05 06 01 0E   ≤ ▌ésf)♠♠↓♪§♦♠☺♫
00 00 00 00.00 00 00 00.00 00 36 30.30 30 30 30           600000
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65 6E 6C 79.6E 74 6F 6E.2E 63 6F 6D.73 6F 66 74   enlynton.comsoft
77 61 72 65.73 75 70 70.6F 72 74 73.76 2E 63 6F   waresupportsv.co
6D 6D 74 63.66 31 30 30.30 30 36 30.30 30 30 30   mmtcf10000600000
31 75 70 64.6D 61 6E 61.67 65 72 2E.63 6F 6D      1updmanager.com
```

('600000', '600000', ‘SERGE-PC…', 'kenlynton.com', 'softwaresupportsv.com', 'mtcf', '10000', '600000', '1', 'updmanager.com', '', '', '', '', '', '', '', '', '', '')

Plugins list

Payload

```
RegisterNewCommand(0, CMD_update_config, 0);
RegisterNewCommand(1, CMD_load_plugin, 0);
RegisterNewCommand(2, CMD_unload_plugin, 0);
RegisterNewCommand(3, CMD_start_keylogger, 0);
RegisterNewCommand(4, CMD_stop_keylogger, 0);
RegisterNewCommand(5, CMD_list_dir, 0);
RegisterNewCommand(6, CMD_read_file, 0);
RegisterNewCommand(7, CMD_write_file, 0);
RegisterNewCommand(8, CMD_delete_file_or_directory, 0);
RegisterNewCommand(9, CMD_get_registry_keys_data, 0);
RegisterNewCommand(10, CMD_write_registry_key_data, 0);
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RegisterNewCommand(12, CMD_list_all_running_processes, 0);
RegisterNewCommand(13, CMD_create_process, 0);
RegisterNewCommand(14, CMD_terminate_process, 0);
RegisterNewCommand(15, CMD_get_module_list, 0);
RegisterNewCommand(17, CMD_get_devices, 0);
RegisterNewCommand(18, CMD_update_SEDRECO, 0);
RegisterNewCommand(19, CMD_read_file_from_offset, 0);
RegisterNewCommand(20, CMD_map_network, 0);
```

Payload

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RegisterNewCommand(20, CMD_map_network, 0);
```

Extending The Core (1)

- Plugins are DLLs loaded in the same address space
- Plugins receive arguments from the core:

```
args.output_buffer = output_buffer;
args.RegisterNewCommand = RegisterNewCommand;
args.FN_read_file = FN_read_file_w_ts;
args.FN_write_output_to_file = FN_write_output_to_file;
args.FN_unregister_command = FN_unregister_command;
args.FN_outbuf_strcat = FN_outbuf_strcat;
v8 = (Init)(&args, hFile, dummy);
```

Extending The Core (1)

- Plugins are DLLs loaded in the same address space
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```
args.output_buffer = output_buffer;
args.RegisterNewCommand = RegisterNewCommand;
args.FN_read_file = FN_read_file_w_ts;
args.FN_write_output_to_file = FN_write_output_to_file;
args.FN_unregister_command = FN_unregister_command;
args.FN_outbuf_strcat = FN_outbuf_strcat;
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args.FN_write_output_to_file = FN_write_output_to_file;
args.FN_unregister_command = FN_unregister_command;
args.FN_outbuf_strcat = FN_outbuf_strcat;
v8 = (Init)(&args, hFile, dummy);
```

Extending The Core (2)

```
int __stdcall Init(ModuleArgs *args)
{
  output_buffer = args->output_buffer;
  FN_RegisterNewCommand = args->RegisterNewCommand;
  FN_unregister_command = args->FN_unregister_command;
  FN_RegisterNewCommand(36, __FN_http_com, 1);
  return 0;
}
```

```
int __stdcall UnInit(int cmd_index)
{
  FN_unregister_command(36);
  return 0;
}
```

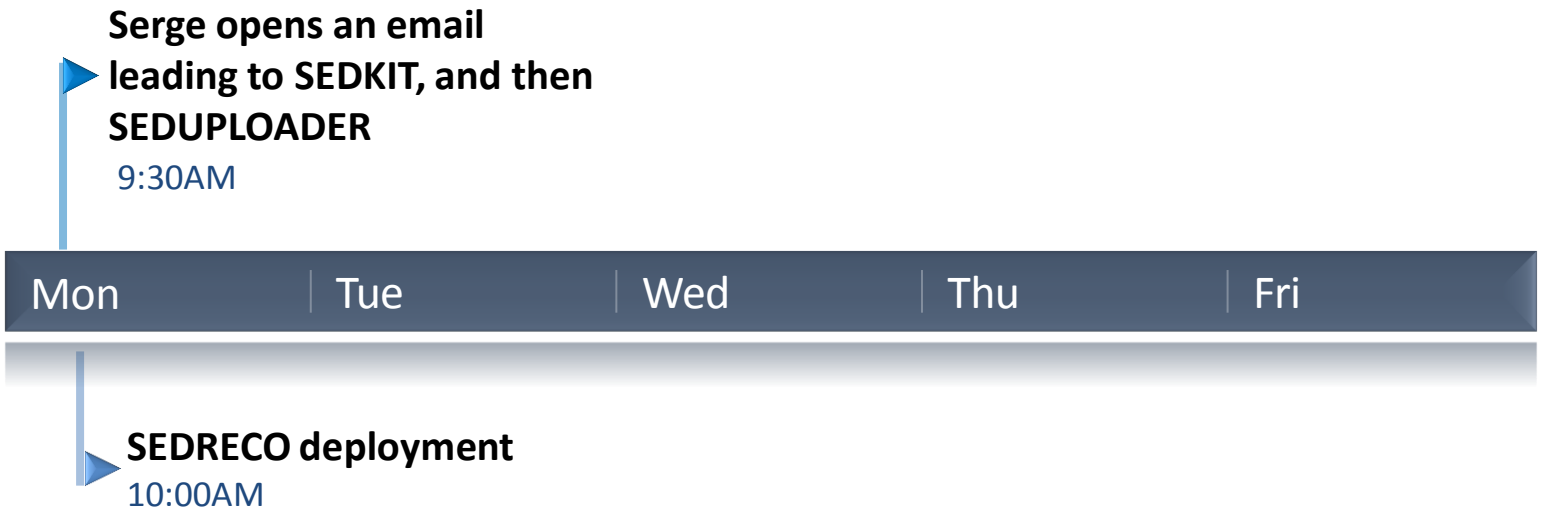
Extending The Core (2)

```
int __stdcall Init(ModuleArgs *args)
{
  output_buffer = args->output_buffer;
  FN_RegisterNewCommand = args->RegisterNewCommand;
  FN_unregister_command = args->FN_unregister_command;
  FN_RegisterNewCommand(36, __FN_http_com, 1);
  return 0;
}
```

New command

```
int __stdcall UnInit(int cmd_index)
{
  FN_unregister_command(36);
  return 0;
}
```

Chain of Events

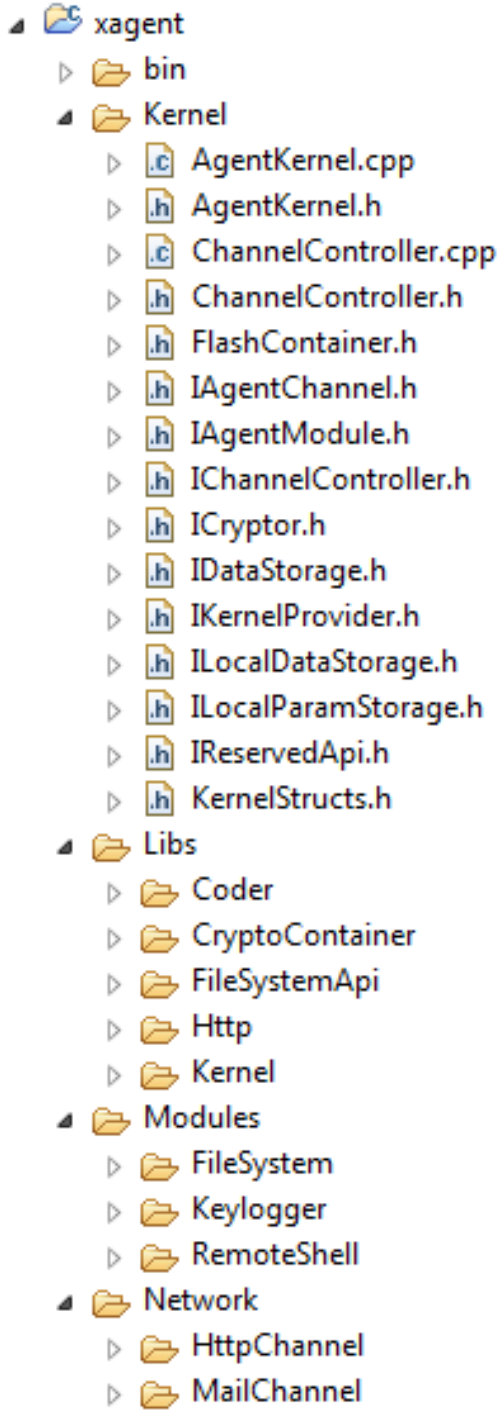


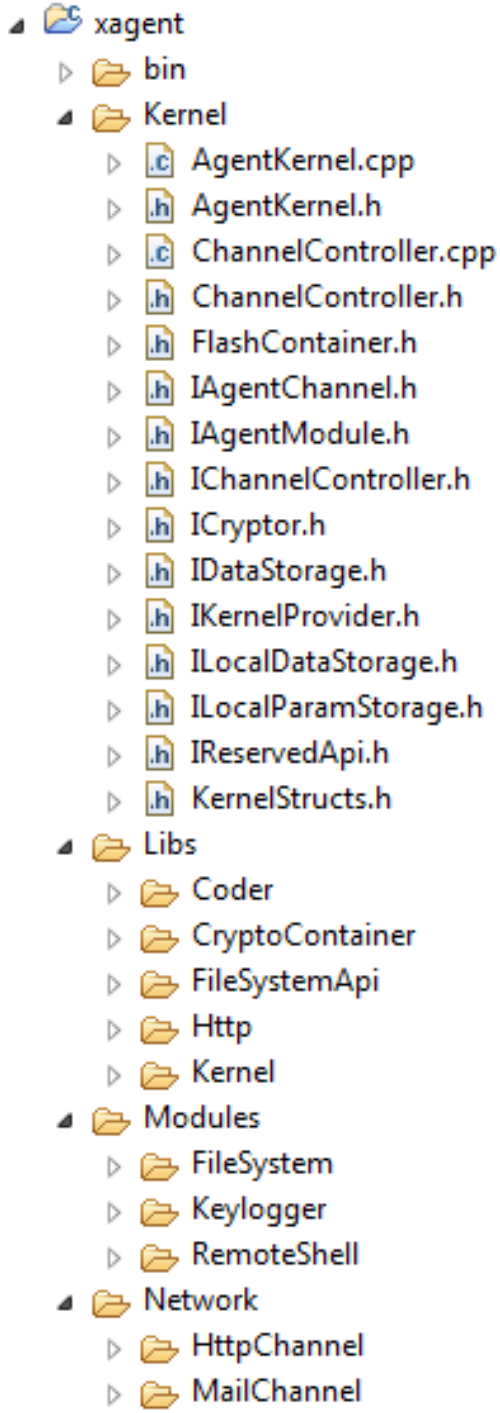
MONDAY, 2:00PM

Serge Meets XAGENT
(a.k.a SPLM, CHOPSTICK)

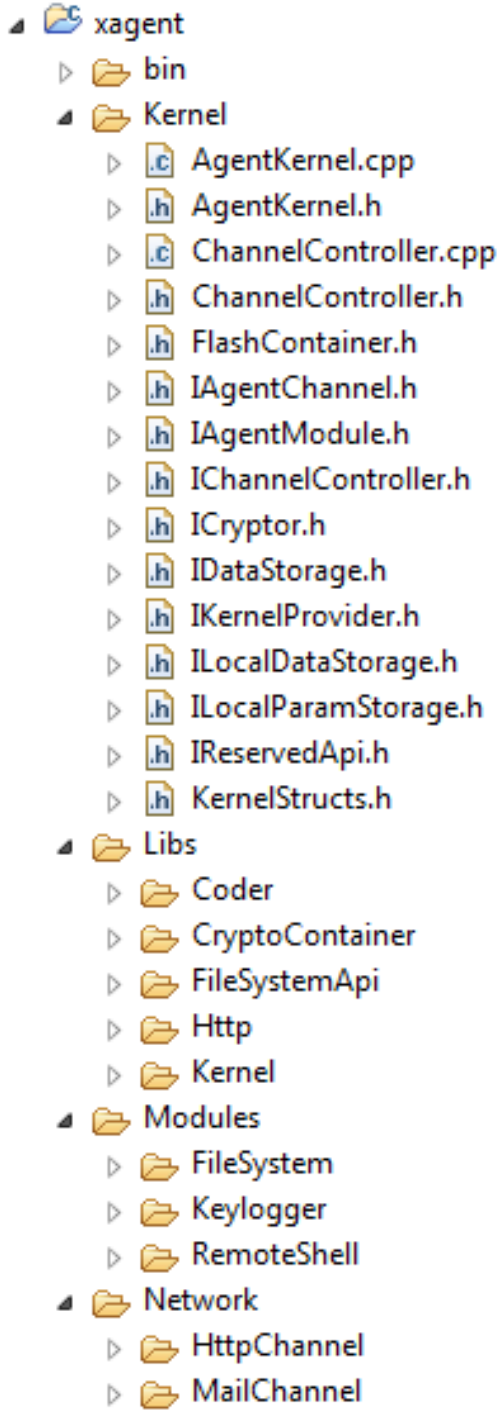
- Downloaded by SEDUPLOADER
- Modular backdoor developed in C++ with Windows, Linux and iOS versions
- Deployed in most Sednit operations, usually after the reconnaissance phase
- Period of activity: November 2012 - Now


ACCESS TO SOURCE CODE...
GRANTED
imgflip.com

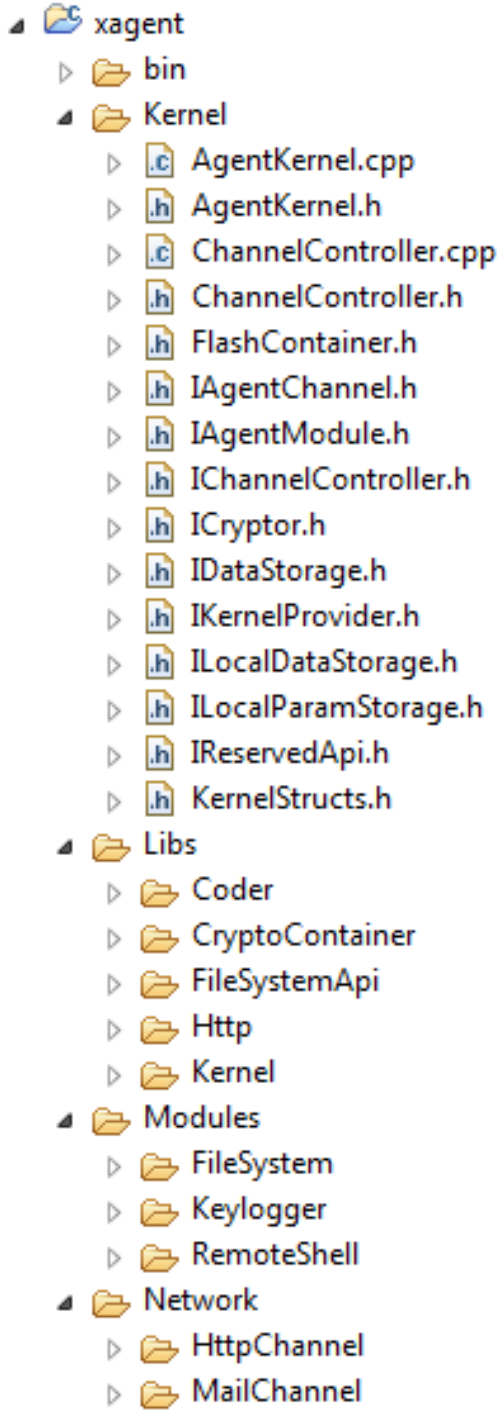

xagent
bin
Kernel
AgentKernel.cpp
AgentKernel.h
ChannelController.cpp
ChannelController.h
FlashContainer.h
IAgentChannel.h
IAgentModule.h
IChannelController.h
ICryptor.h
IDataStorage.h
IKernelProvider.h
ILocalDataStorage.h
ILocalParamStorage.h
IReservedApi.h
KernelStructs.h
Libs
Coder
CryptoContainer
FileSystemApi
Http
Kernel
Modules
FileSystem
Keylogger
RemoteShell
Network
HttpChannel
MailChannel



- Linux XAGENT, compiled in July 2015

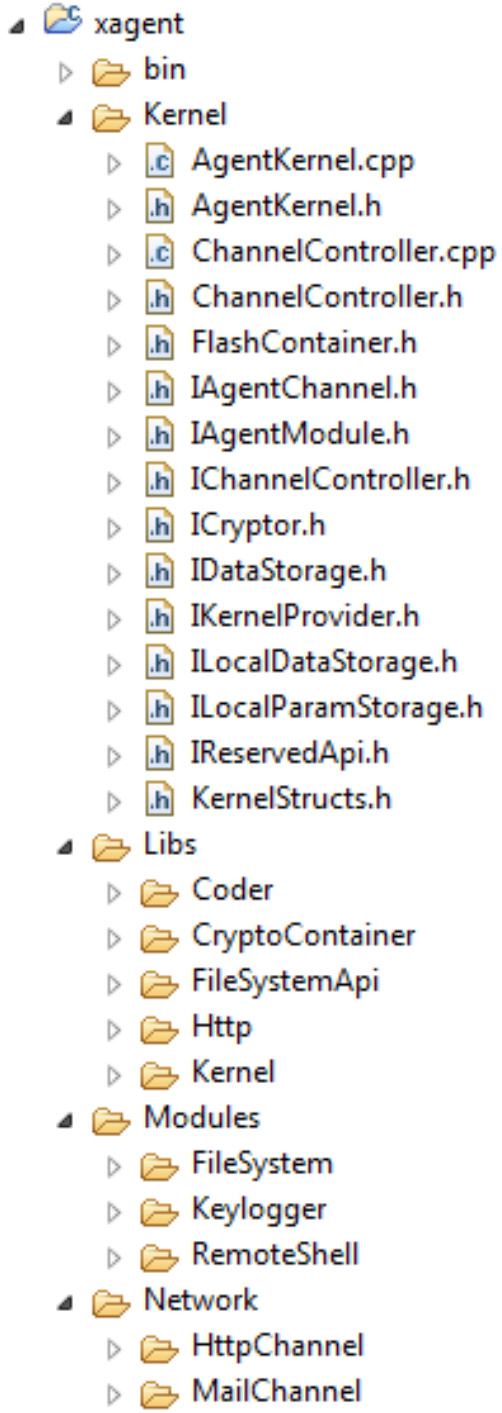


- Linux XAGENT, compiled in July 2015
- ~ 18,000 lines of code in 59 classes



- Linux XAGENT, compiled in July 2015
- ~ 18,000 lines of code in 59 classes
- Derives from Windows version:

```
if(handleGetPacket != 0)
{
    pthread_exit(&handleGetPacket);
    //TerminateThread(handleGetPacket, 0);
    //CloseHandle(handleGetPacket);
}
```



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```
if(handleGetPacket != 0)
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    pthread_exit(&handleGetPacket);
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}
```

- XAGENT major version 2, but matches the logic of currently distributed binaries (version 3)

Such Comments

```
//TODO: Remove fucking defines!!!!
// Packet Header Format
/*
     __4 байта__  _____________________нефиксированная длина_____________________
    /           \/                                                               \
    ##################################################################################
    # Agent ID  #                          CRYPT DATAS                             #
    ##################################################################################
*/
```

```
// TODO: AGENT ID !!!
// FIXME: CONSTANT AGENT ID!!!
// Write Agent ID
*(int *)data = msg->getAgentID();
```

```
// Указатель на данные
//    int        short      char      a lot of of bytes
// AGENT_ID | MODULE_ID | CMD_ID | MES_DATA
```

<- That's a lot

```
int startXAgent(wstring path)
{
    [...]

    AgentKernel krnl( (wchar_t *)path.c_str() );

    IAgentChannel* http_channel = new HttpChannel();
    //IAgentChannel* smtp_channel = new MailChannel();

    IAgentModule* remote_shell = new RemoteShell();
    IAgentModule* file_system = new FSModule();
    //IAgentModule* key_log = new RemoteKeylogger();

    krnl.registerChannel(http_channel);
    //krnl.registerChannel(smtp_channel);
    krnl.registerModule(remote_shell);
    krnl.registerModule(file_system);
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    krnl.startWork();

    [...]
}
```

main.cpp

```
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    [...]
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```

① ②

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}
```

① ② ③

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① ② ③ ④

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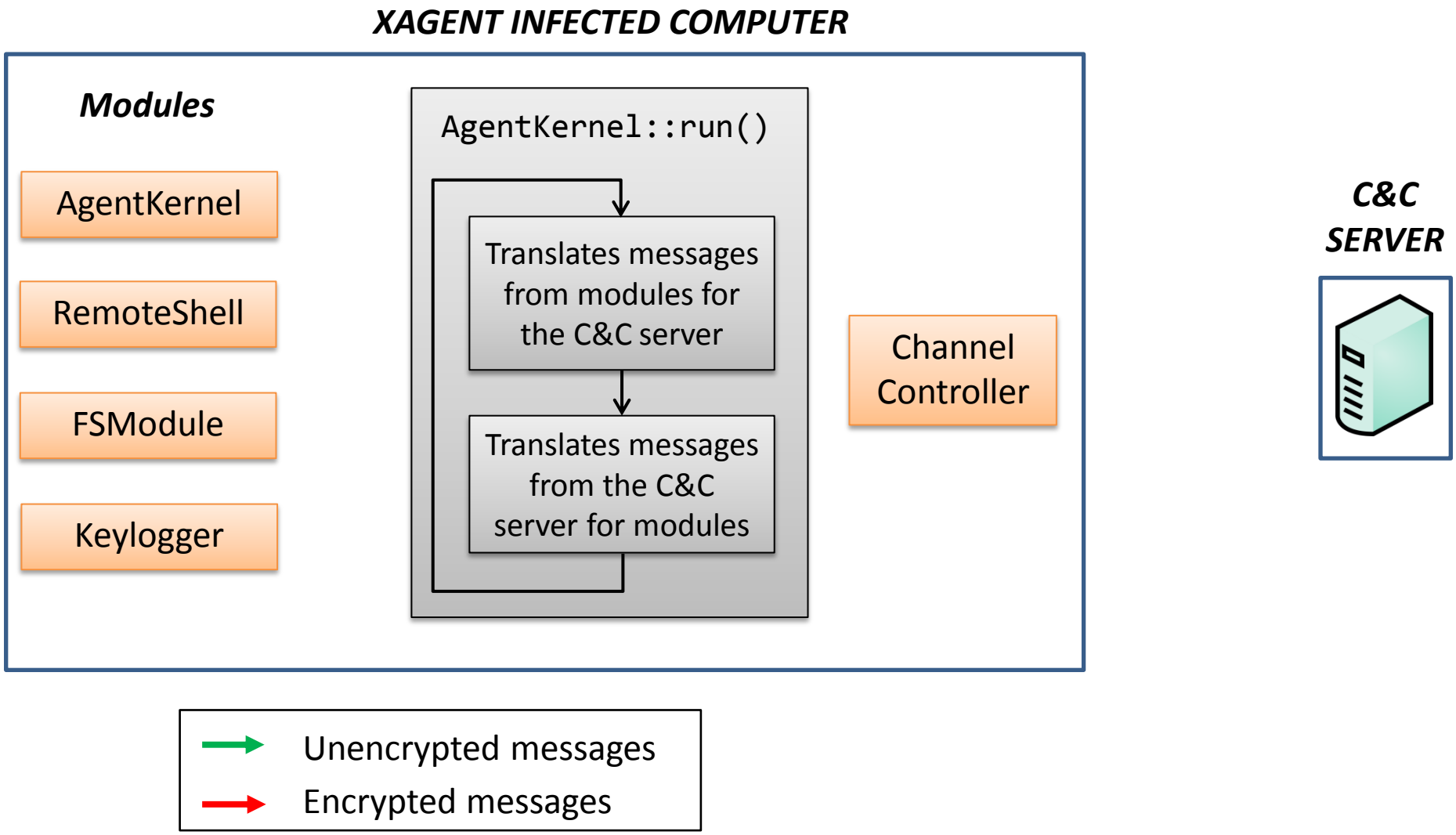
}
```

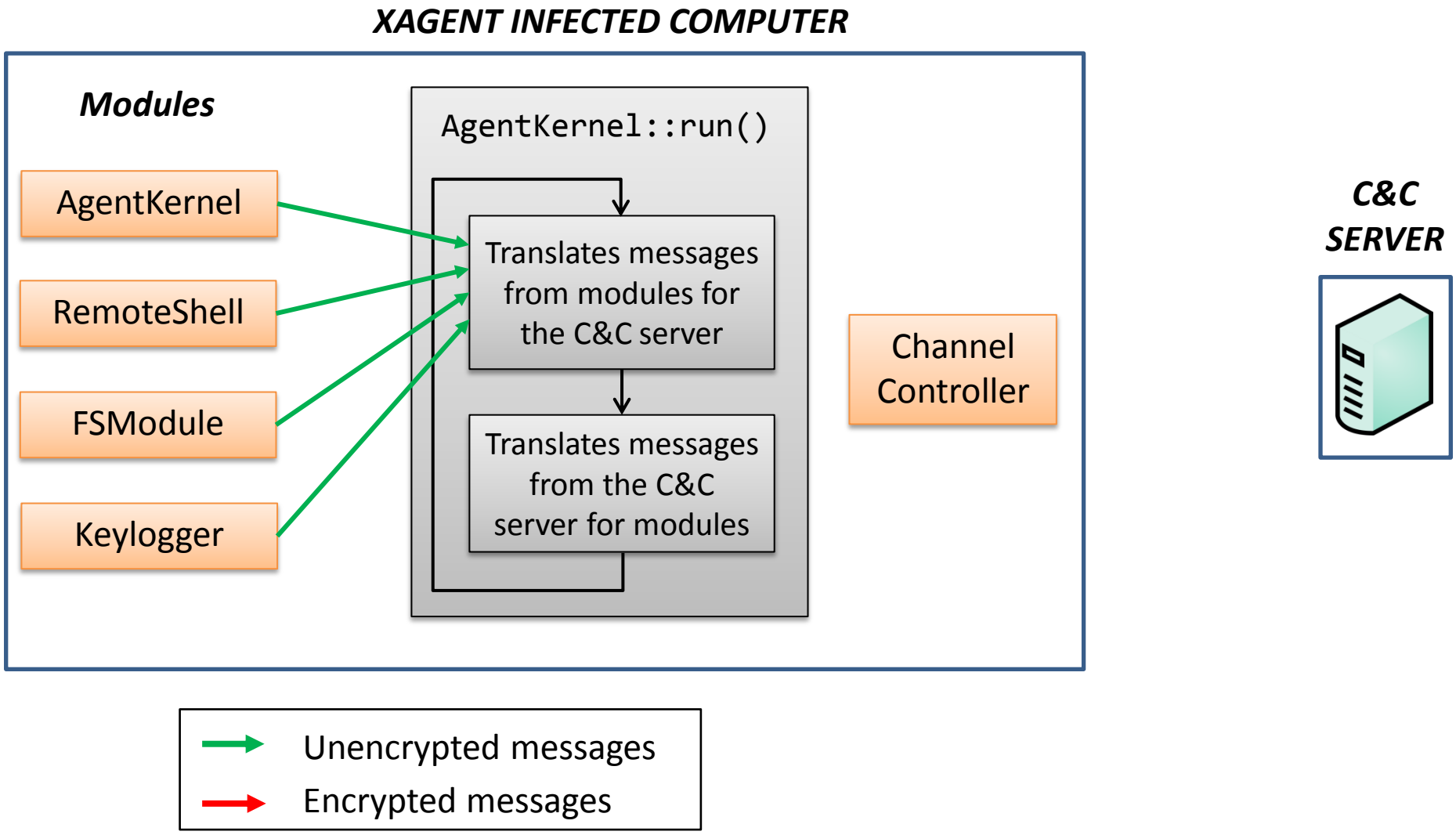
① ② ③ ④ ⑤

main.cpp

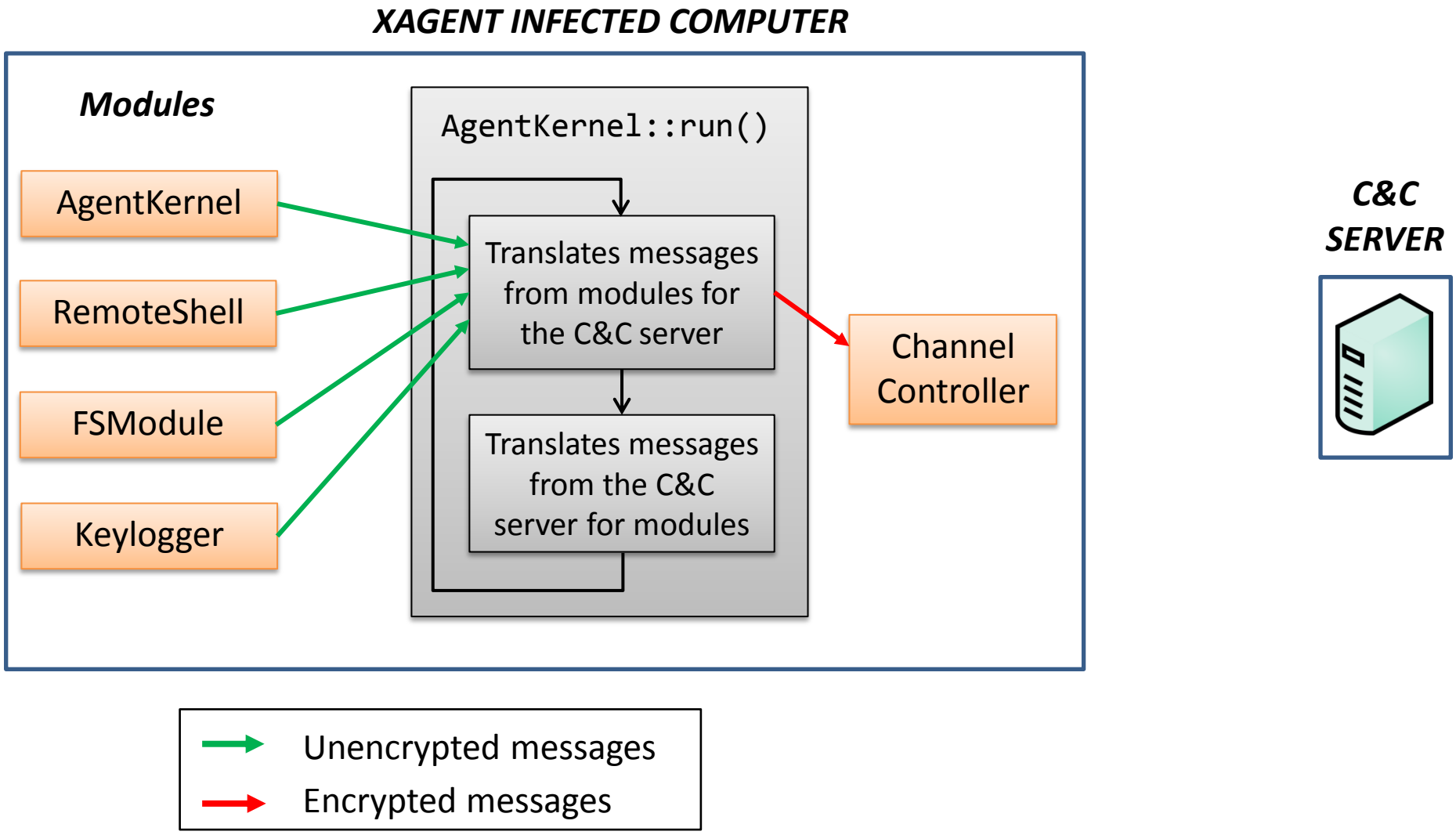
Communication Workflow



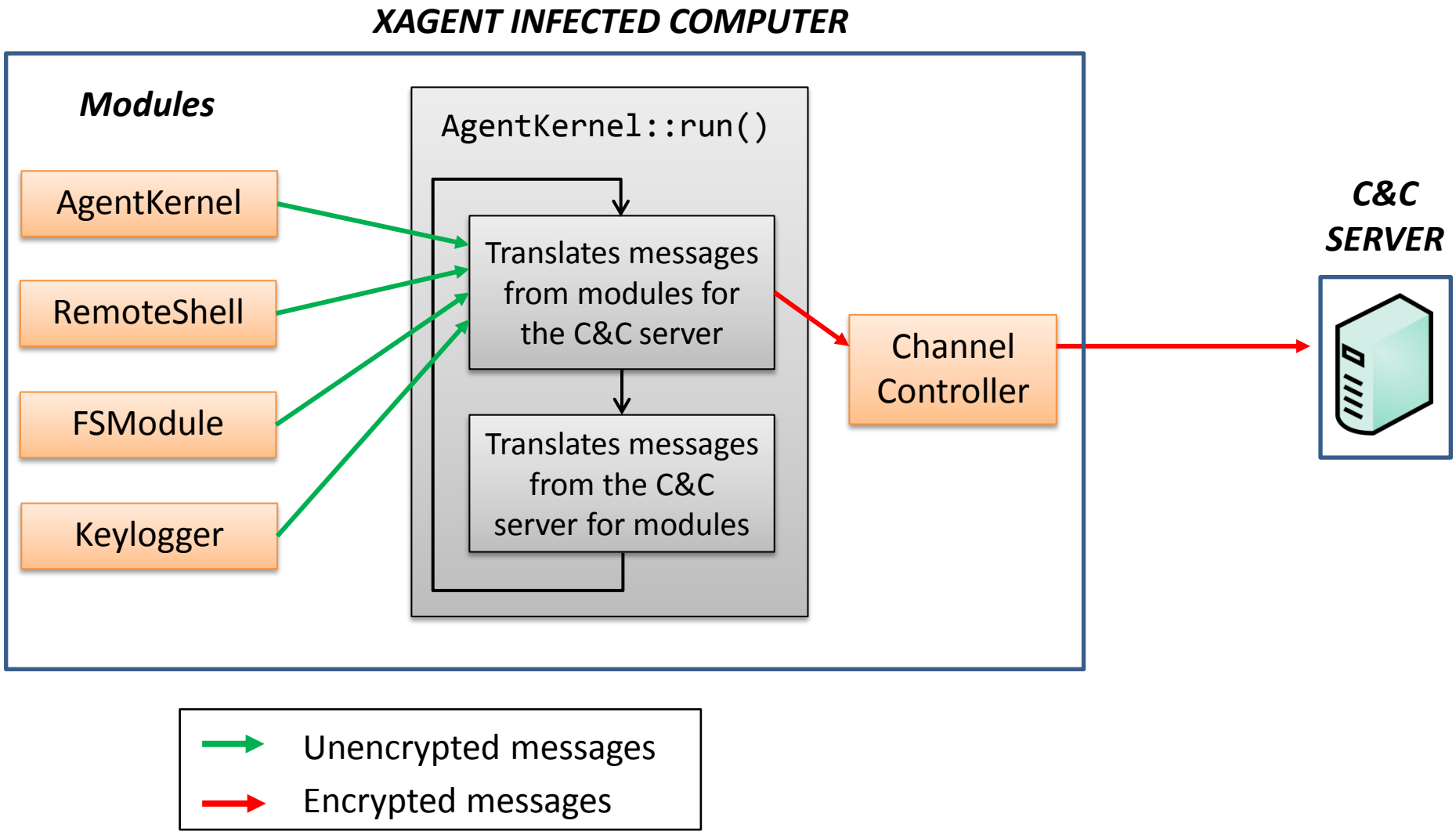
Communication Workflow



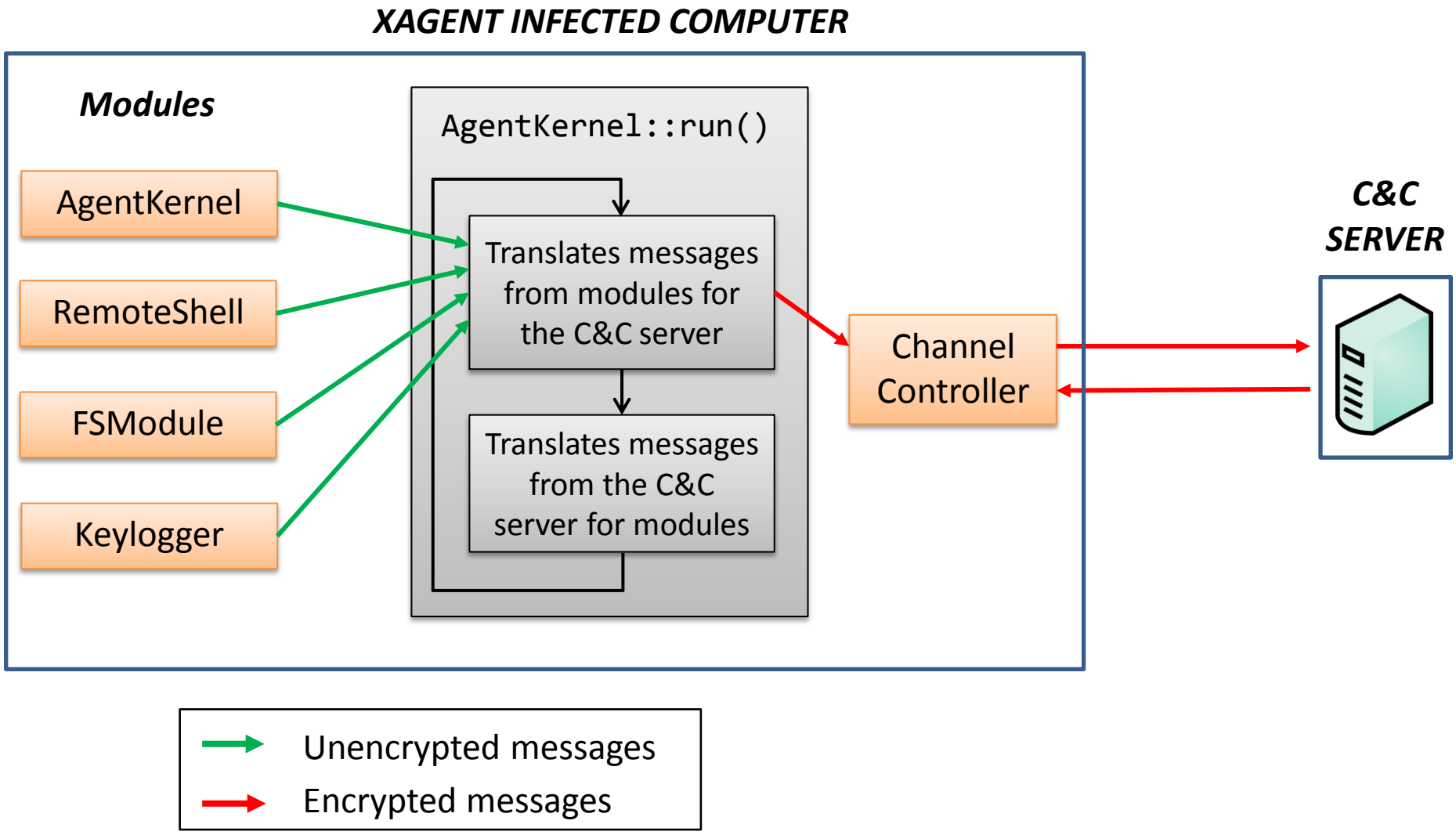
Communication Workflow



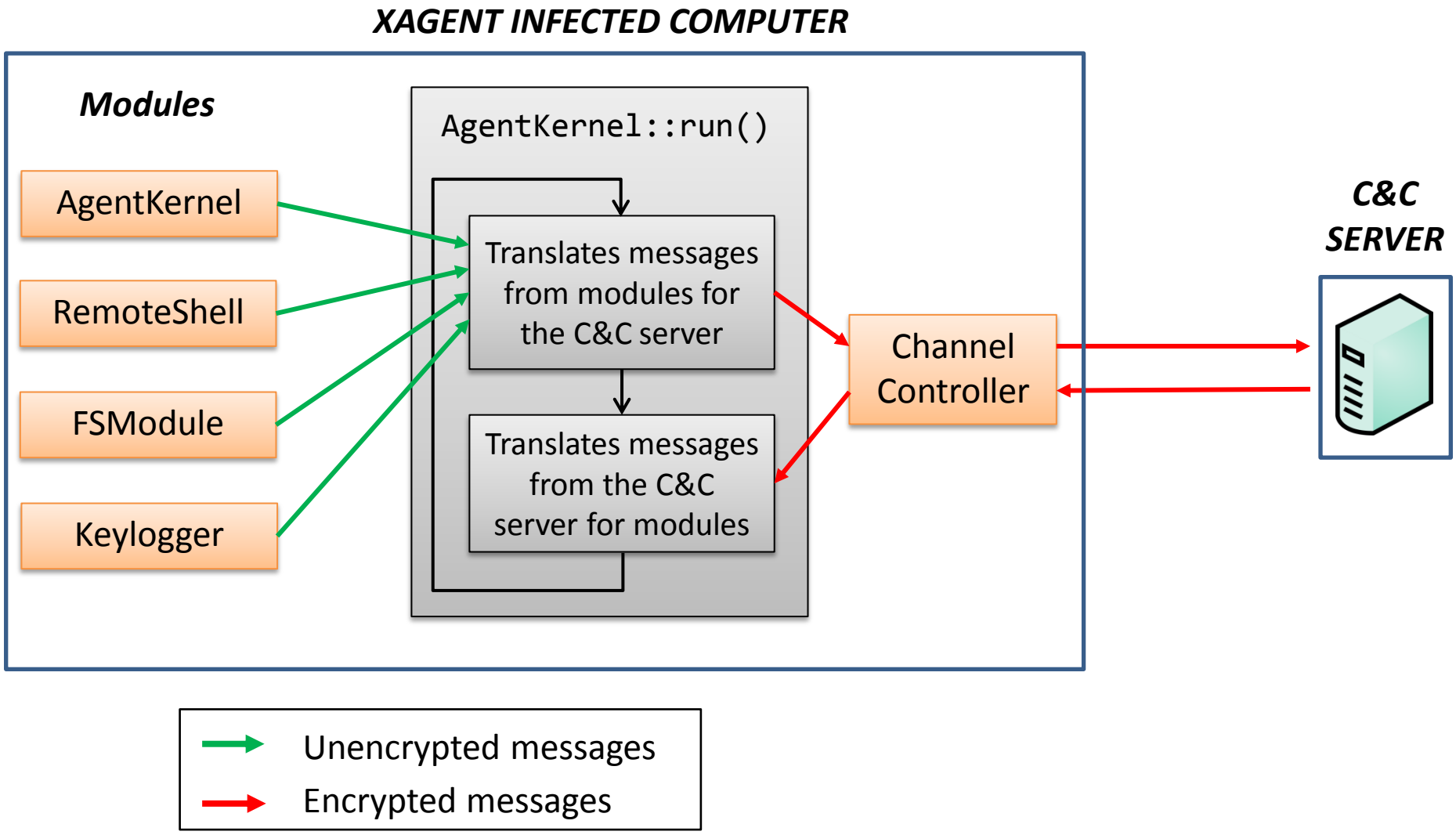
Communication Workflow



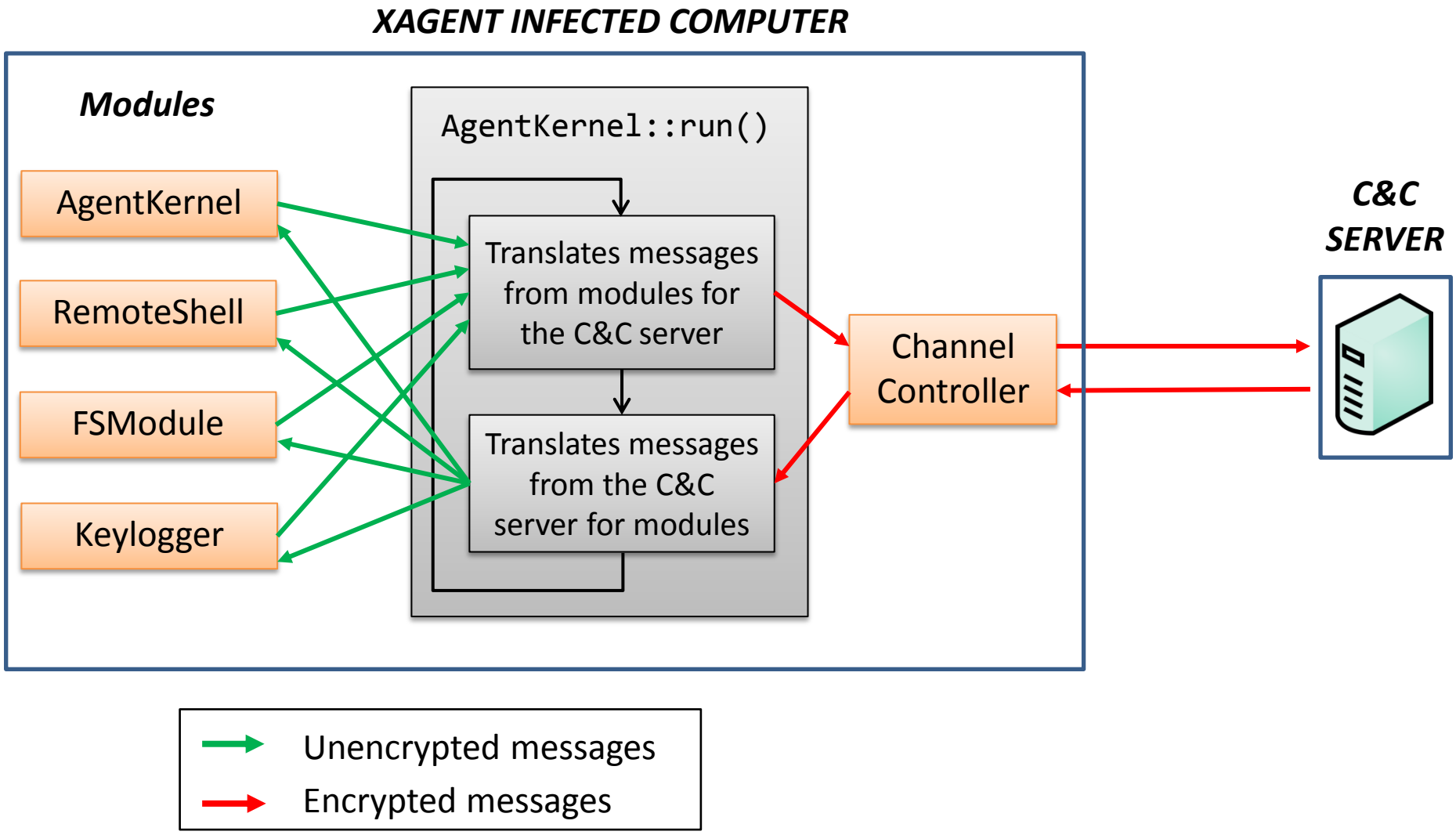
Communication Workflow



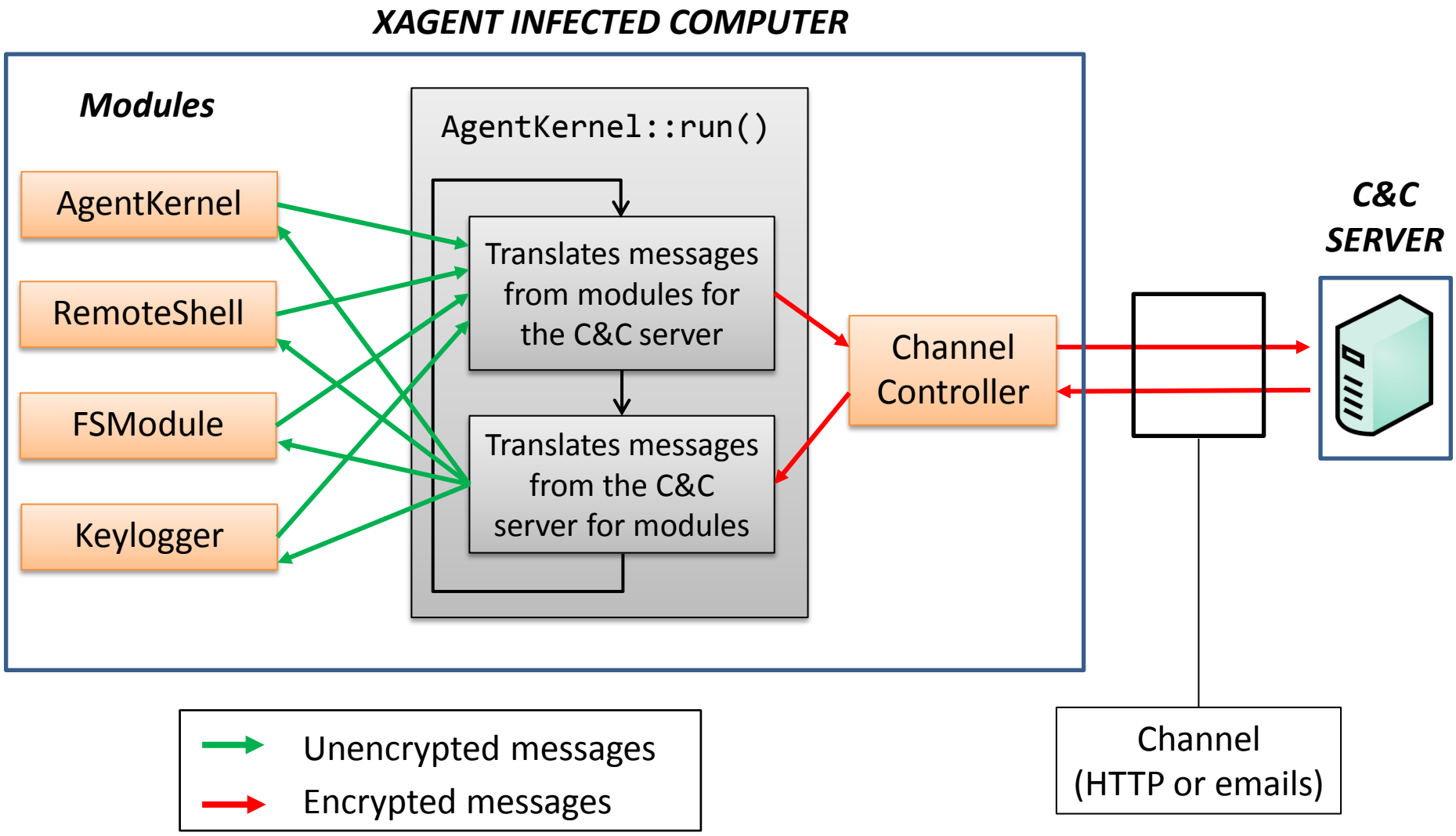
Communication Workflow



Communication Workflow

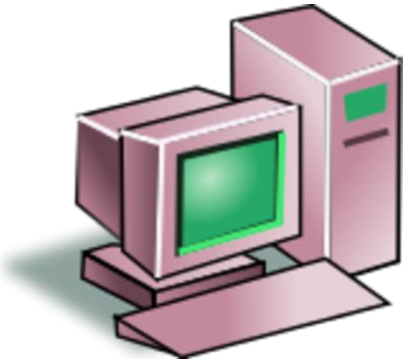


Communication Workflow



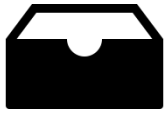
Emails Channel (1)

Workflow



XAGENT INFECTED COMPUTER USING MailChannel

exfil@gmail.com

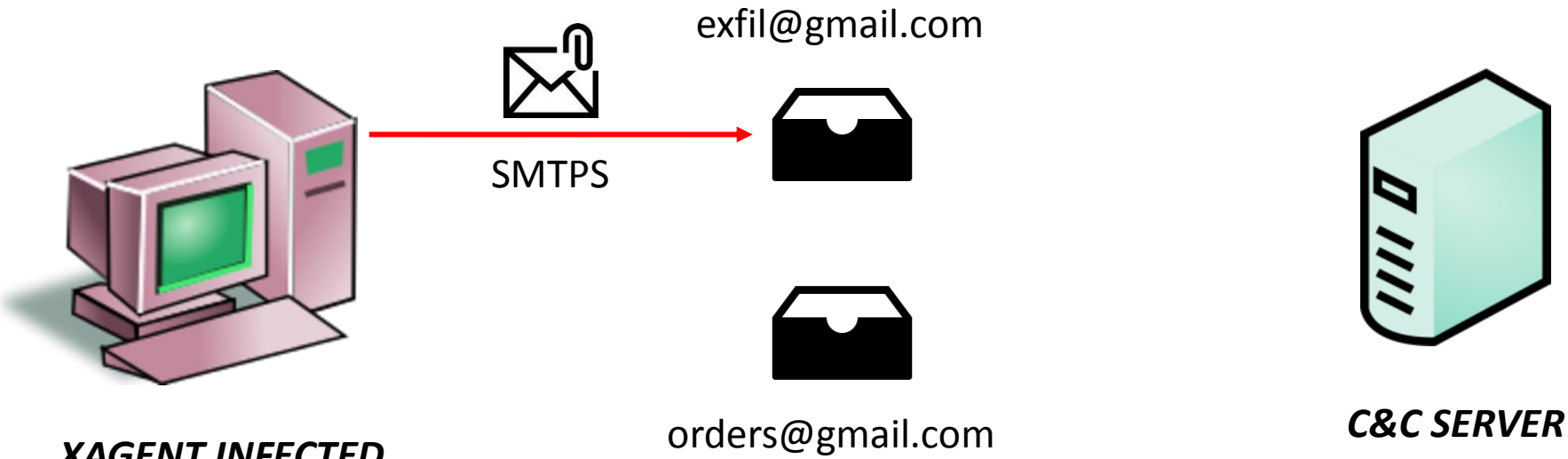


orders@gmail.com

C&C SERVER

Emails Channel (1)

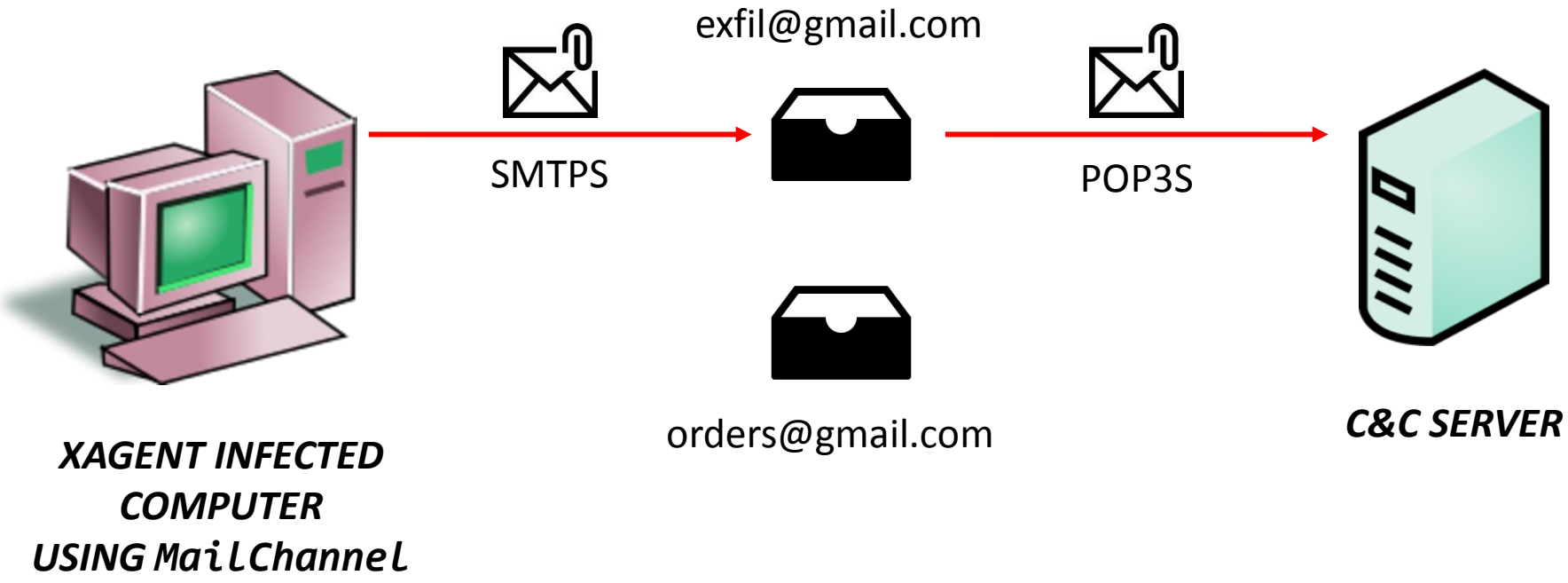
Workflow



XAGENT INFECTED COMPUTER USING MailChannel

Emails Channel (1)

Workflow



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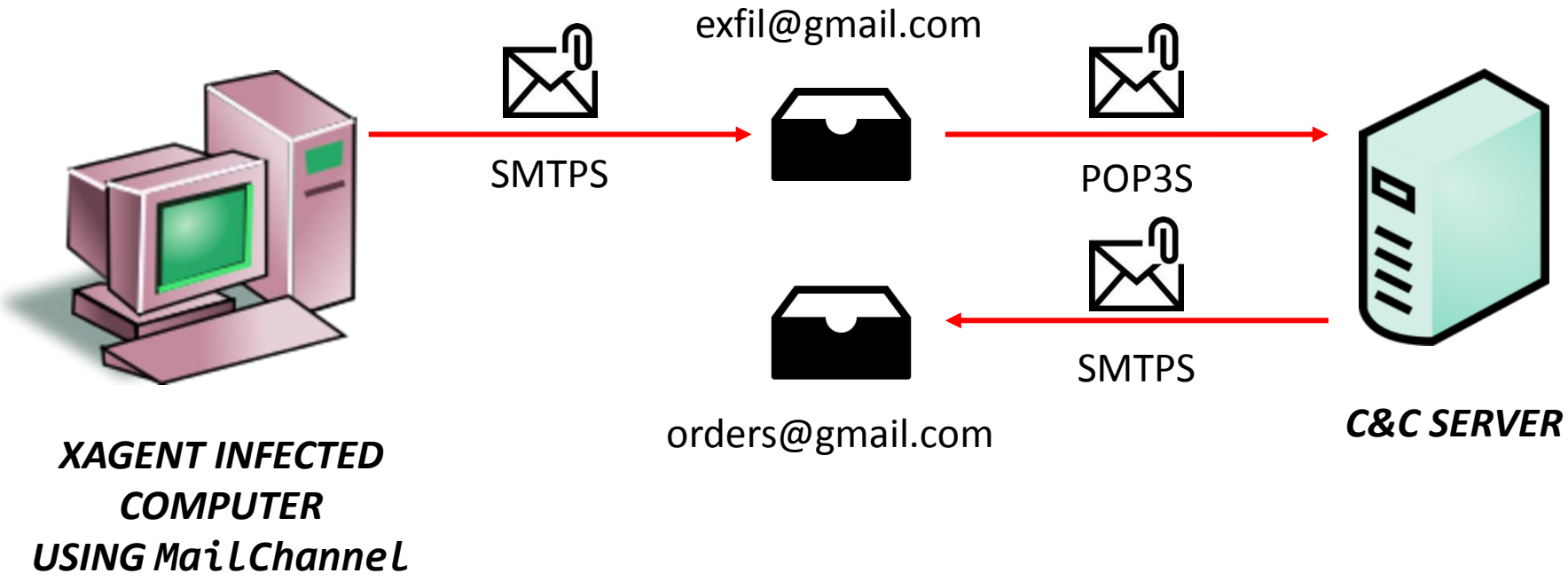

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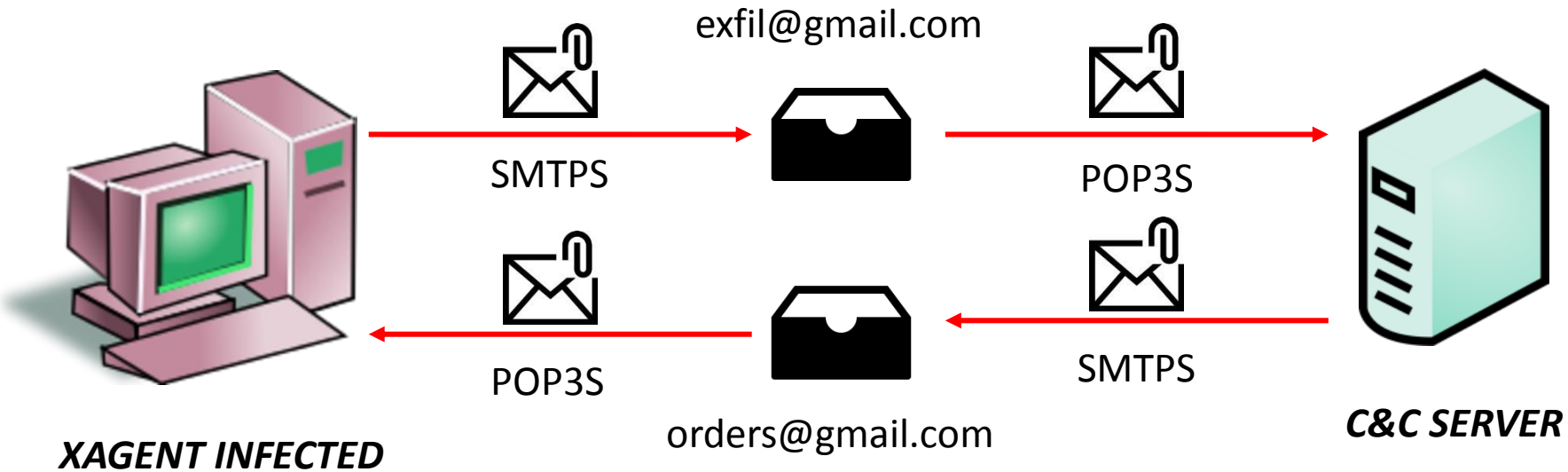

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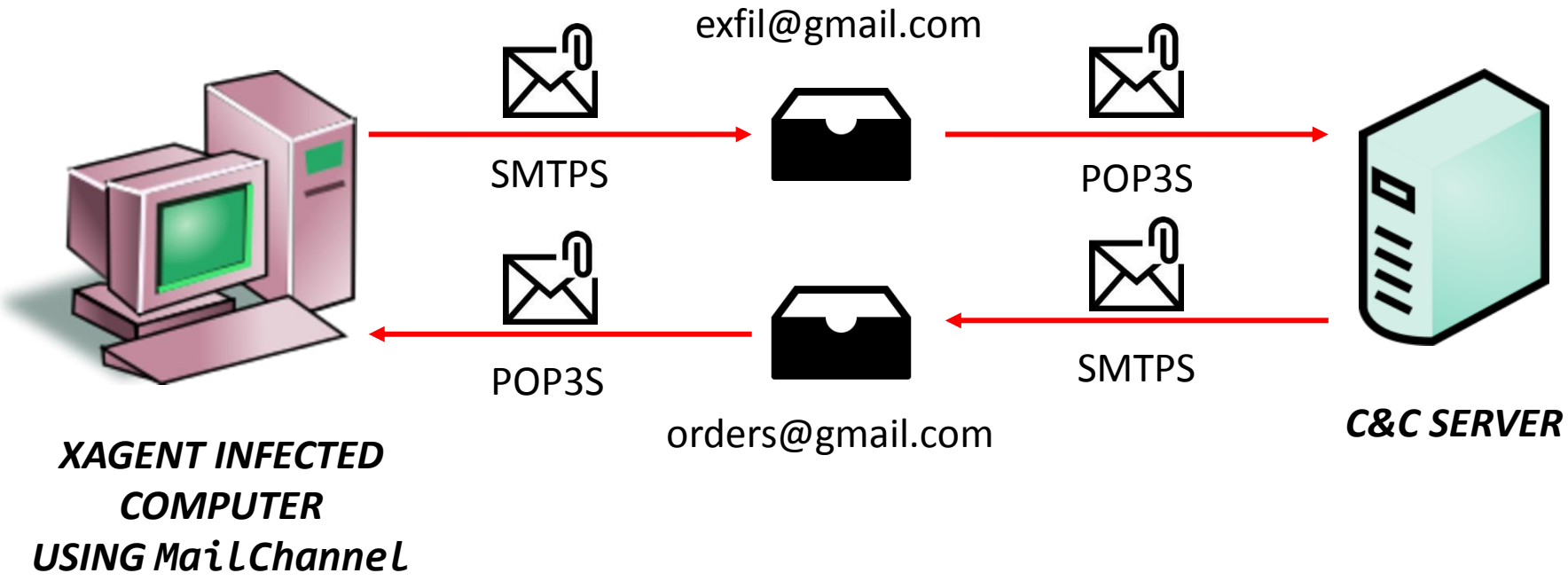
Workflow

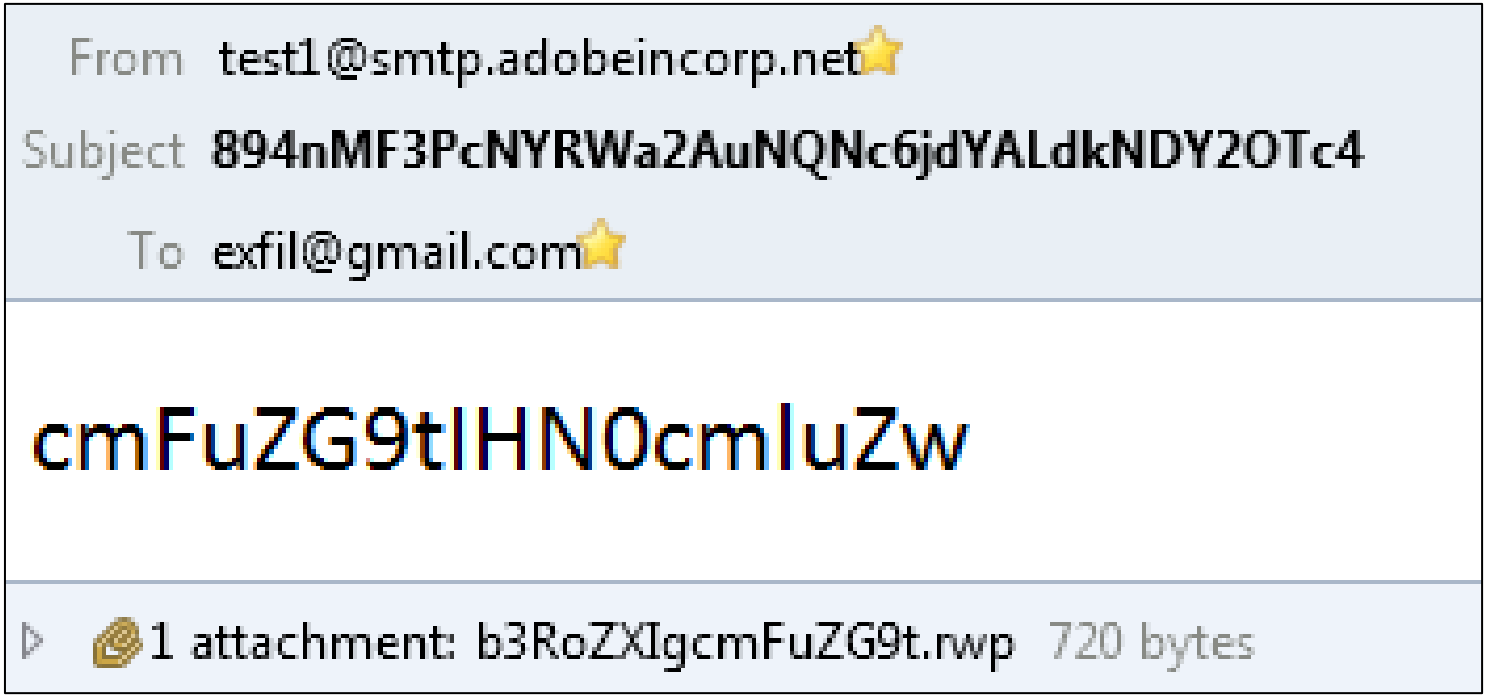


An email-based C&C protocol needs to provide:

1. A way to distinguish C&C emails from unrelated emails
2. A way to bypass spam filters

Email Channel (2)

P2Scheme, a.k.a “Level 2 Protocol”



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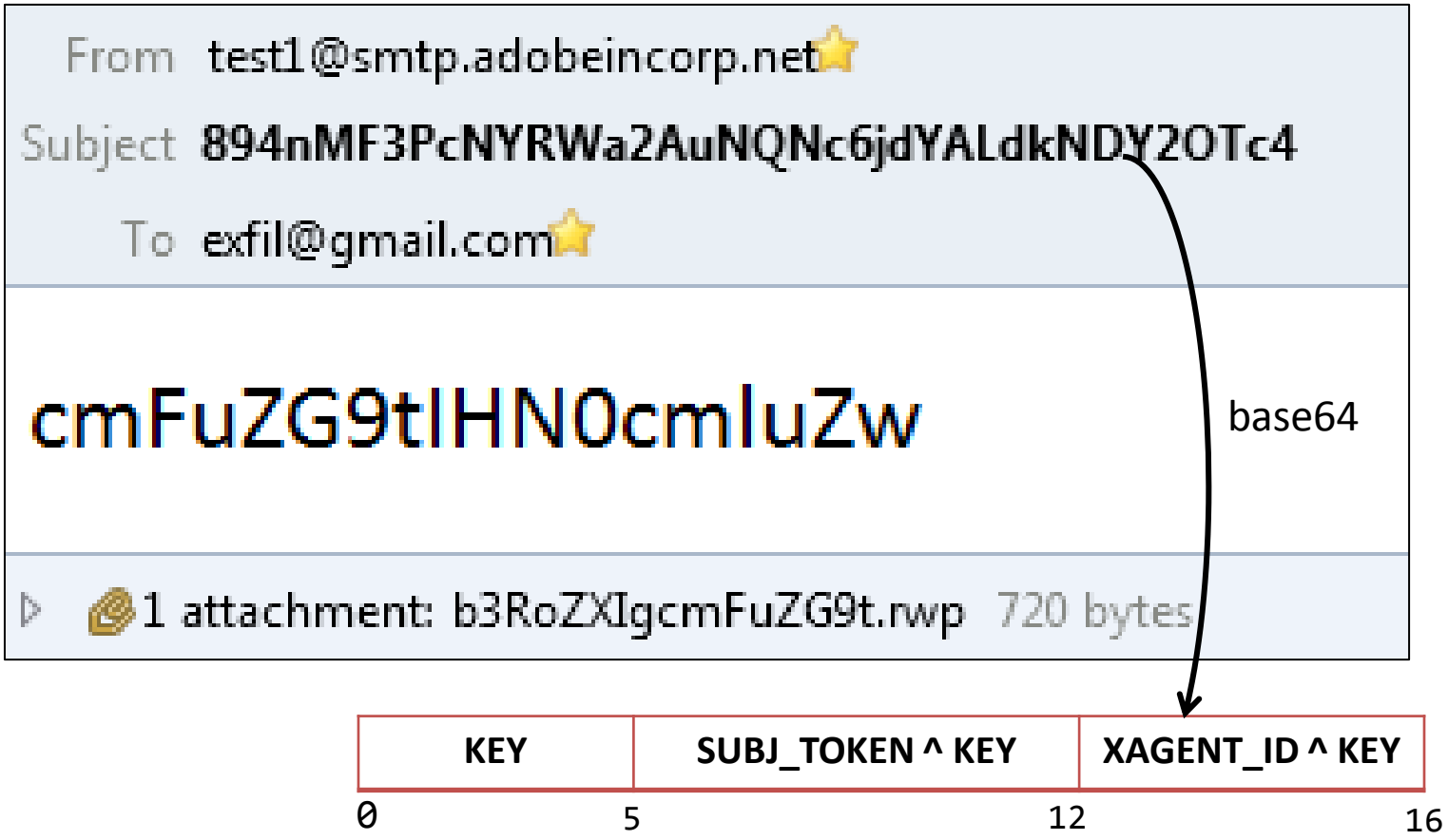

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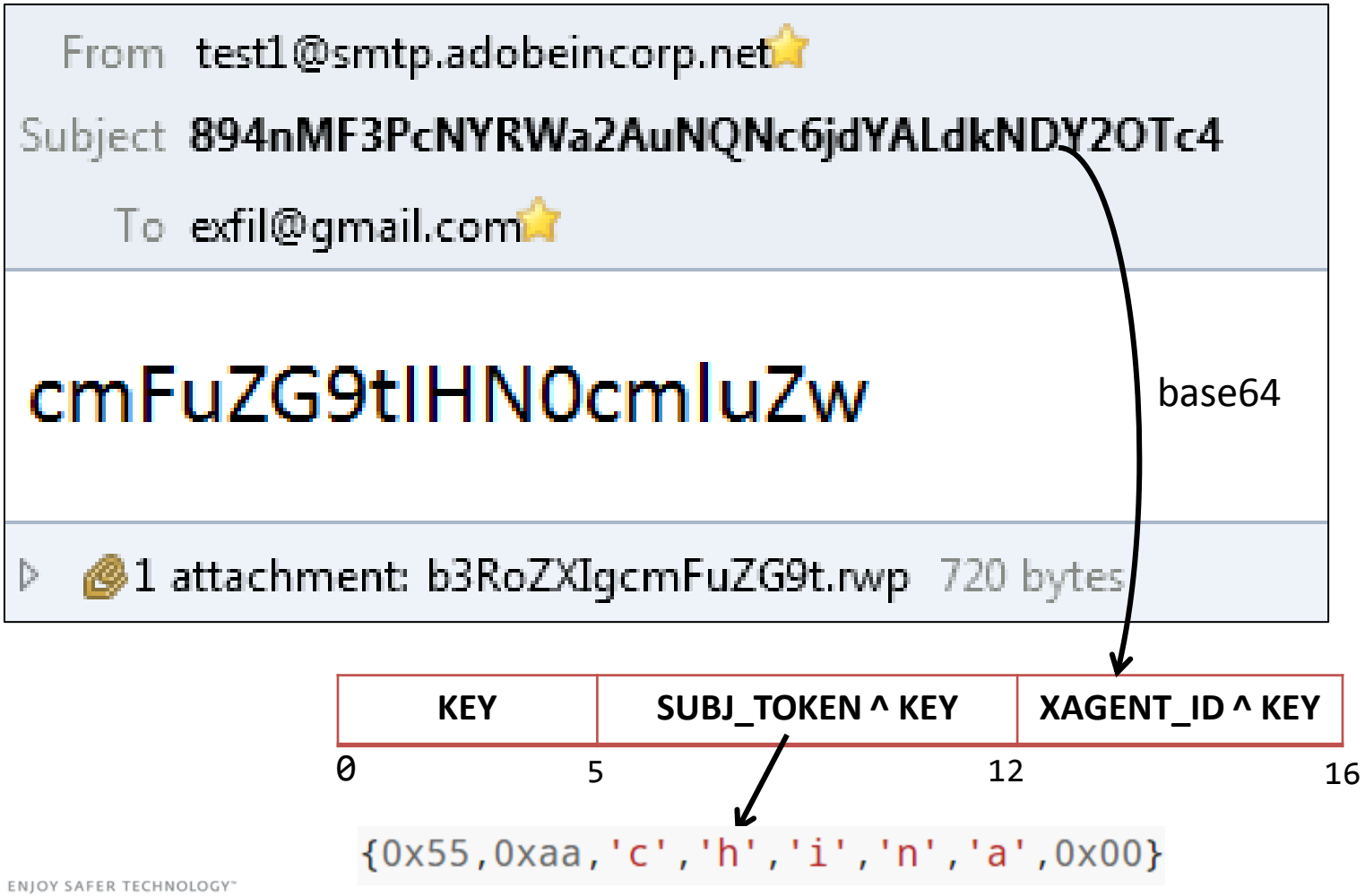
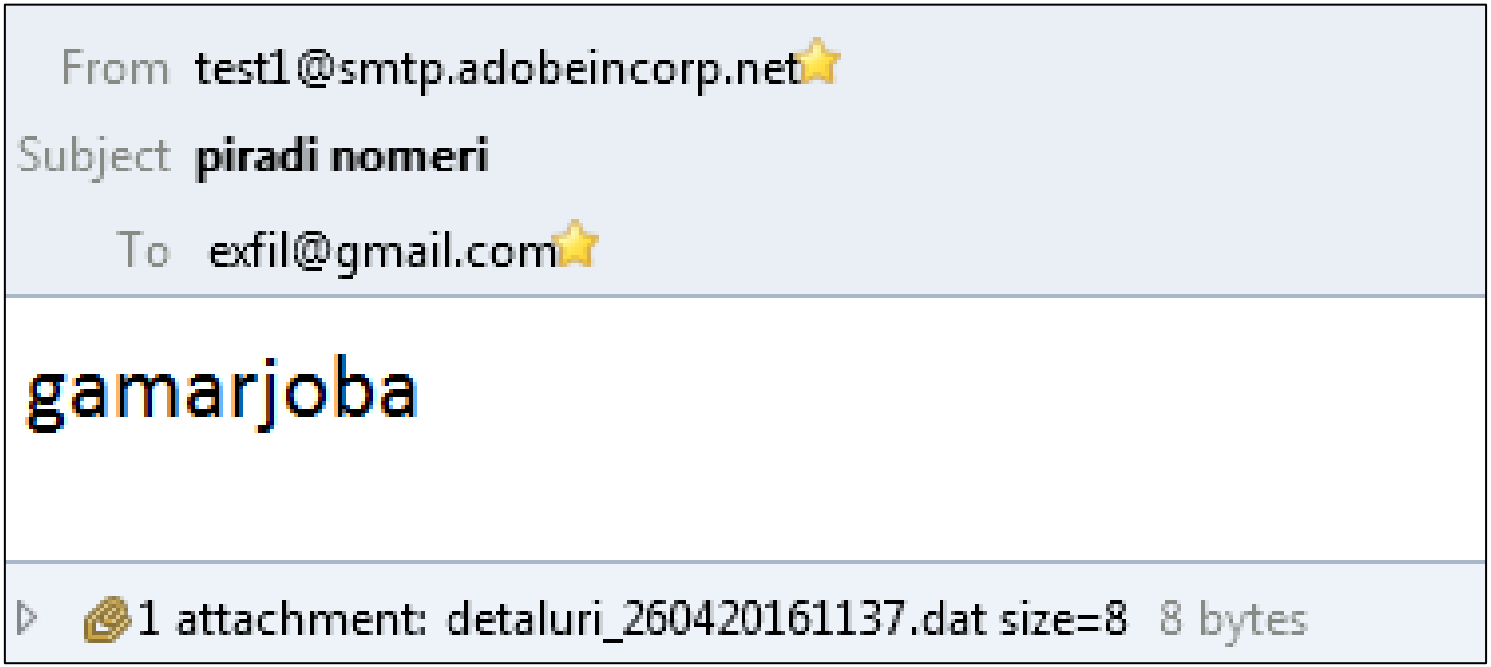


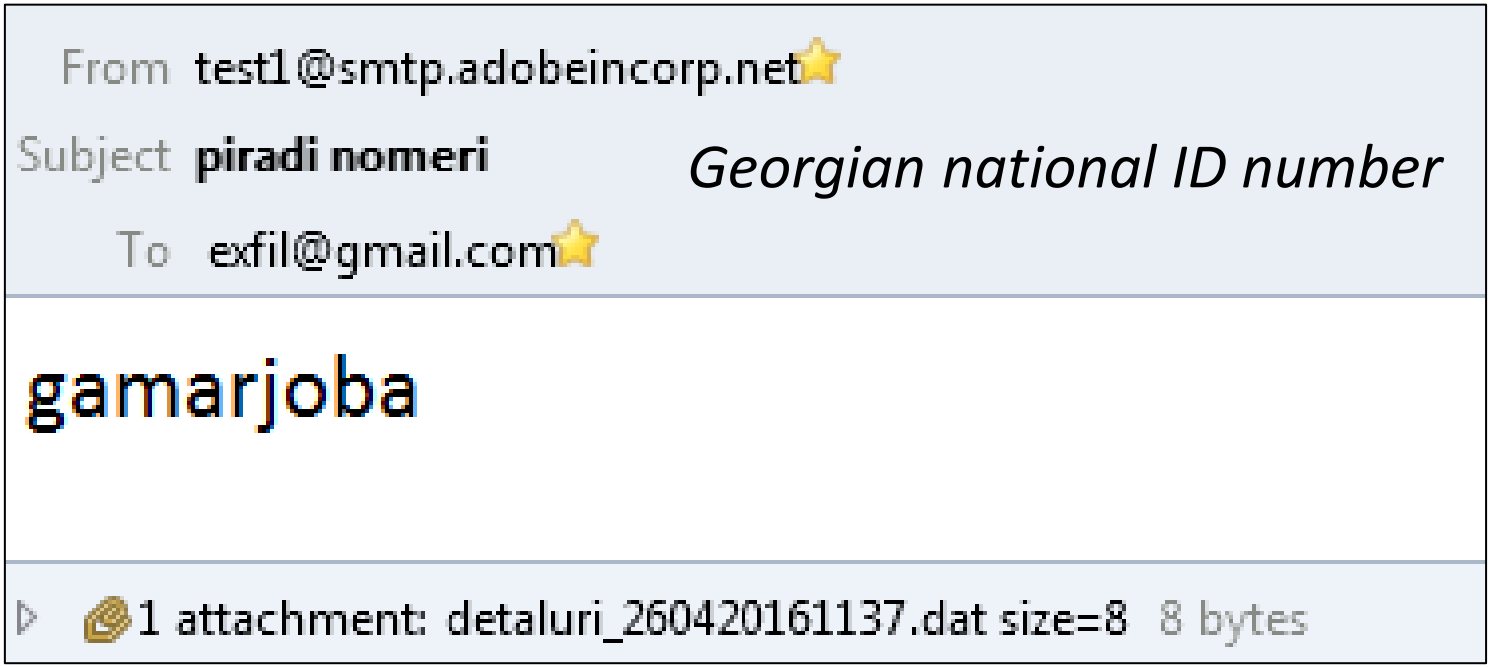
Email Channel (3)

Georgian Protocol



Email Channel (3)

Georgian Protocol



Email Channel (3)

Georgian Protocol

Email Channel (3)

Georgian Protocol

Georgian national ID number

"Hello"

"detailed" + timestamp

Bonus: XAGENT C&C Infrastructure

Bonus: XAGENT C&C Infrastructure

Thank you, Google search engine

XAGENT Proxy Server

__init__.py
_w3.log
_w3server.log
ConsoleLogger.py
FileConsoleLogger.py
FSLocalStorage.py
MailServer.py
MailServer2.py
MailServer3.py
P2Scheme.py
P3Scheme.py
quickstart.py
settings.py
w3s.py
wsgi.py
WsgiHttp.py
XABase64.py

- Python code used between April and June 2015

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- ~ 12,200 lines of code

XAGENT Proxy Server

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wsgi.py
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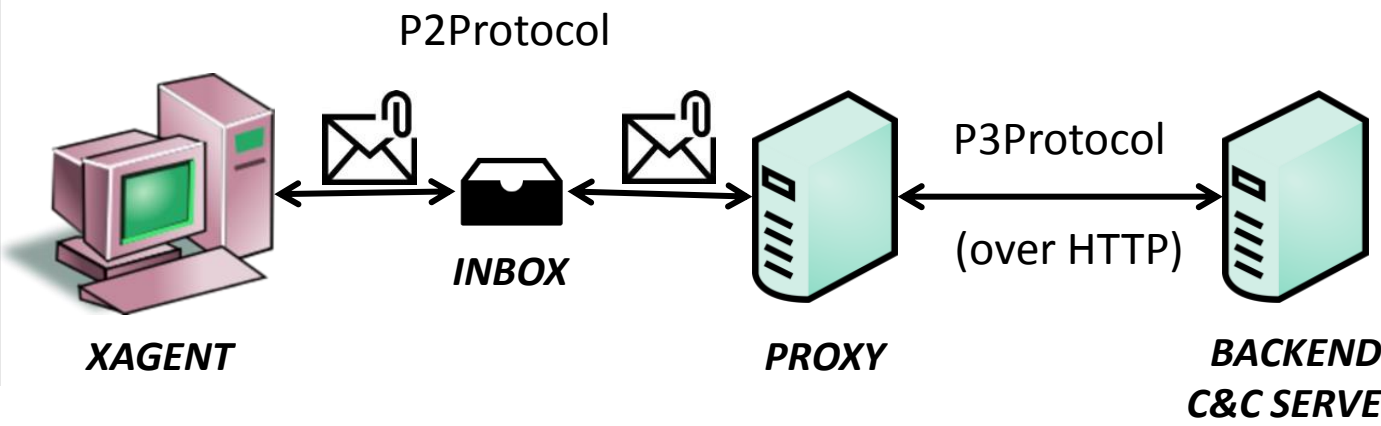
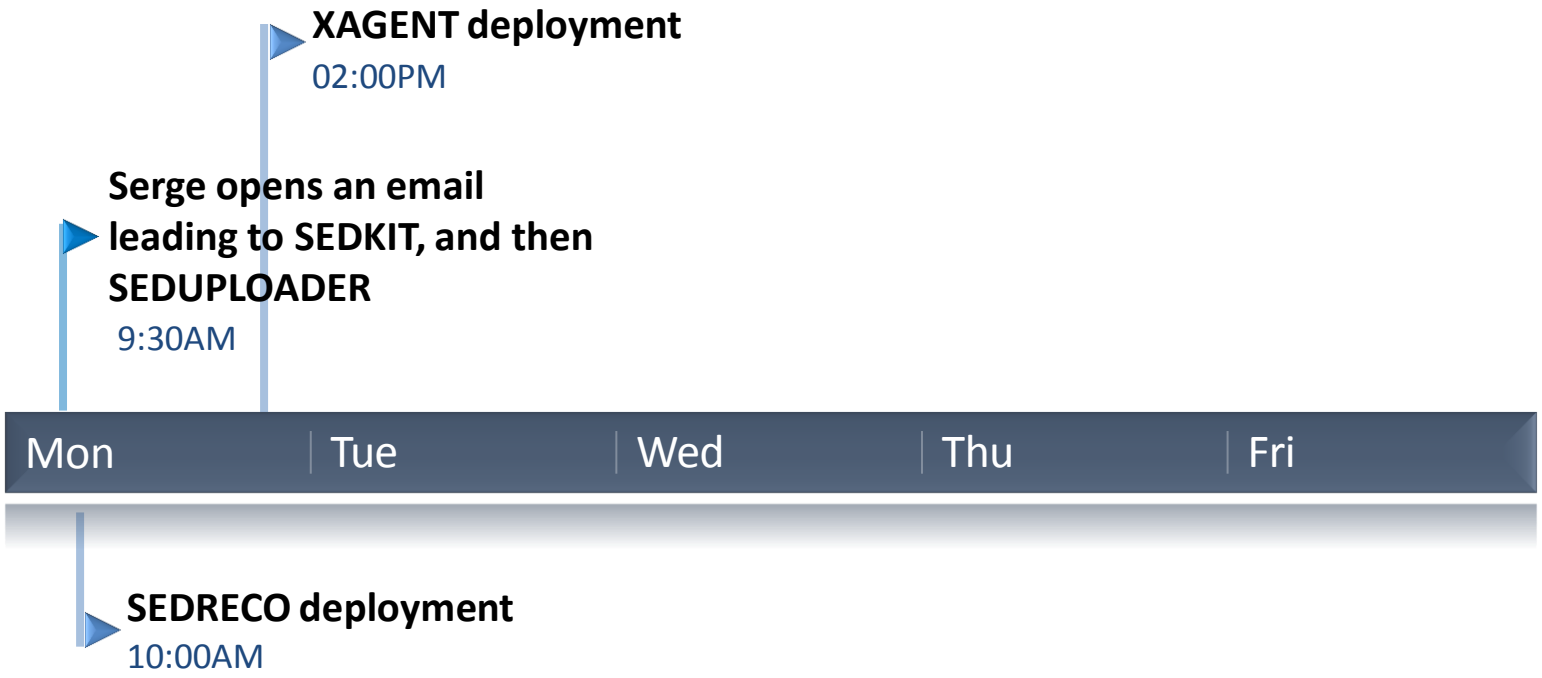
XABase64.py

- Python code used between April and June 2015
- ~ 12,200 lines of code
- Translates email protocol from XAGENT into a HTTP protocol for the C&C server:



Chain of Events



NEXT THREE DAYS...

Serge Meets Passwords Extractors

- SecurityXploded tools (grand classic of Sednit)
  - Cons: usually detected by AV software

- Custom tools, in particular a Windows Live Mail passwords extractor compiled for Serge:

```
push    esi
push    offset aFolder  ; "D:\\Mail
call    sub_401590
```

Serge Meets Windows Passwords Extractors

- From registry hives
  - Deployed with LPE for CVE-2014-4076

```
"save hklm\\system C:\\Windows\\system.save", 0,
"save hklm\\security C:\\Windows\\security.save",
"save hklm\\sam C:\\Windows\\sam.save", 0, 0);
```

- Good ol' Mimikatz ("pi.log")
  - Deployed with LPE for CVE-2015-1701

Serge Meets Screenshoter

- Custom tool to take screenshots each time the mouse moves

```
do
{
  GetCursorPos(&Point);
  v5 = Point.x;
  v7 = Point.y;
  Sleep(0x7D0u);
  GetCursorPos(&Point);
  if ( Point.x != v5 || Point.y != v7 )
    FN_TakeScreenshots(&v9, v4++);
}
while ( v4 < 14 );
```

And… Serge Meets XTUNNEL

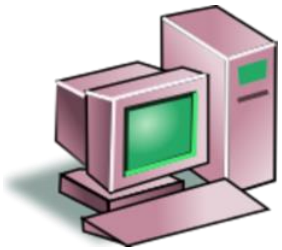
- Network proxy tool to contact machines normally unreachable from Internet
- Period of activity: May 2013 - Now

Initial Situation

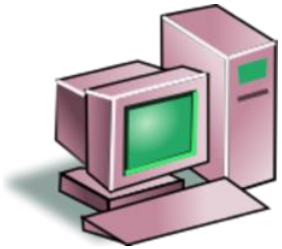
C&C SERVER

INTERNET

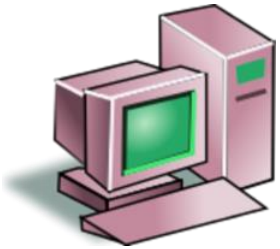
INTERNAL NETWORK



SERGE'S COMPUTER (XTUNNEL INFECTED)



COMPUTER A (CLEAN)



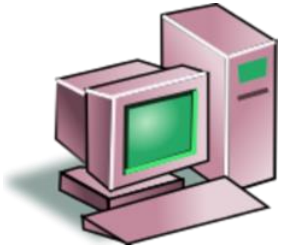
COMPUTER B (CLEAN)

Encryption Handshake

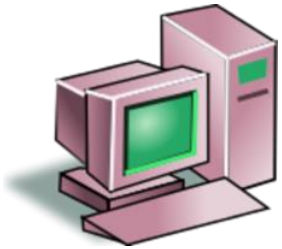
C&C SERVER

INTERNET

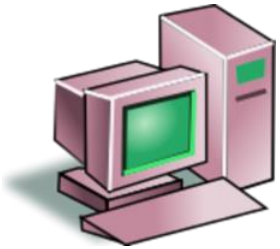
INTERNAL NETWORK



SERGE'S COMPUTER (XTUNNEL INFECTED)



COMPUTER A (CLEAN)



COMPUTER B (CLEAN)

Encryption Handshake

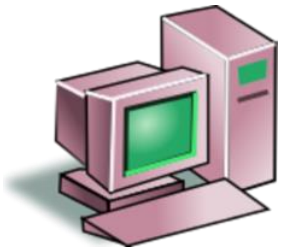
C&C SERVER

```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…
```

T

INTERNET

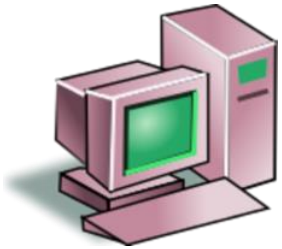
INTERNAL NETWORK



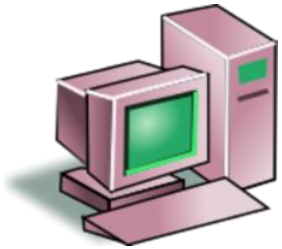
SERGE'S COMPUTER (XTUNNEL INFECTED)

```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…
```

T



COMPUTER A (CLEAN)



COMPUTER B (CLEAN)

Encryption Handshake

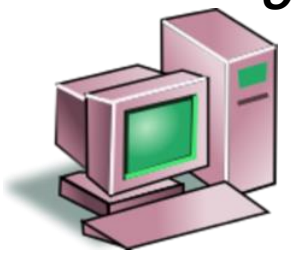
C&C SERVER

```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…
```

T

INTERNET

INTERNAL NETWORK

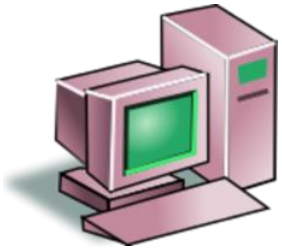


SERGE'S COMPUTER (XTUNNEL INFECTED)

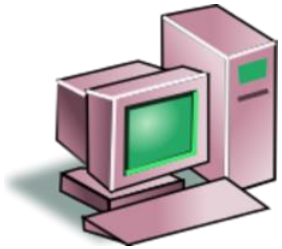
O

```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…  RC4 key
```

T



COMPUTER A (CLEAN)



COMPUTER B (CLEAN)

Encryption Handshake

C&C SERVER

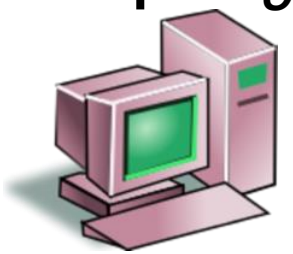
```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…
```

T

INTERNET

- Offset ***O*** in ***T***
- Proof of knowledge of ***T***

INTERNAL NETWORK

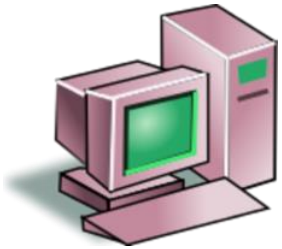


O

```
D5 47 A4 A4.3F 60 6A 0F
3B 36 04 1C.44 4A C8 BD
80 BE 7B 25.8E E6 FC F2
CD 5D 7F 3A.73 1D 59 A5
2D 35 77 F3.B2 1B DF 7D
EE 1D 1C F1.AB 91 87 87
…
```

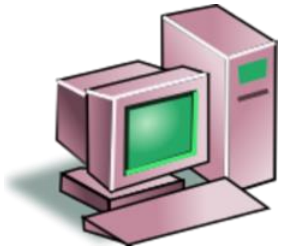
RC4 key

T



COMPUTER A (CLEAN)

SERGE'S COMPUTER (XTUNNEL INFECTED)



COMPUTER B (CLEAN)

Encryption Handshake

C&C SERVER

o →

D5	47	A4	A4.3F	60	6A	0F	
3B	36	04	1C.44	4A	C8	BD	
80	BE	7B	25.8E	E6	FC	F2	
CD	5D	7F	3A.73	1D	59	A5	
2D	35	77	F3.B2	1B	DF	7D	
EE	1D	1C	F1.AB	91	87	87	
…							

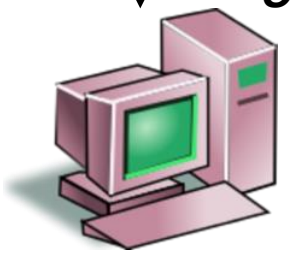
RC4 Key

T

INTERNET

"OK"

INTERNAL NETWORK

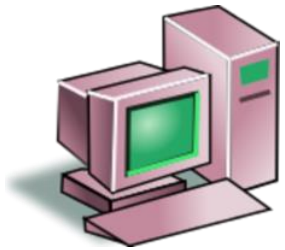


o →

D5	47	A4	A4.3F	60	6A	0F	
3B	36	04	1C.44	4A	C8	BD	
80	BE	7B	25.8E	E6	FC	F2	
CD	5D	7F	3A.73	1D	59	A5	
2D	35	77	F3.B2	1B	DF	7D	
EE	1D	1C	F1.AB	91	87	87	
…							

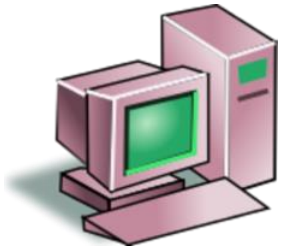
RC4 key

T



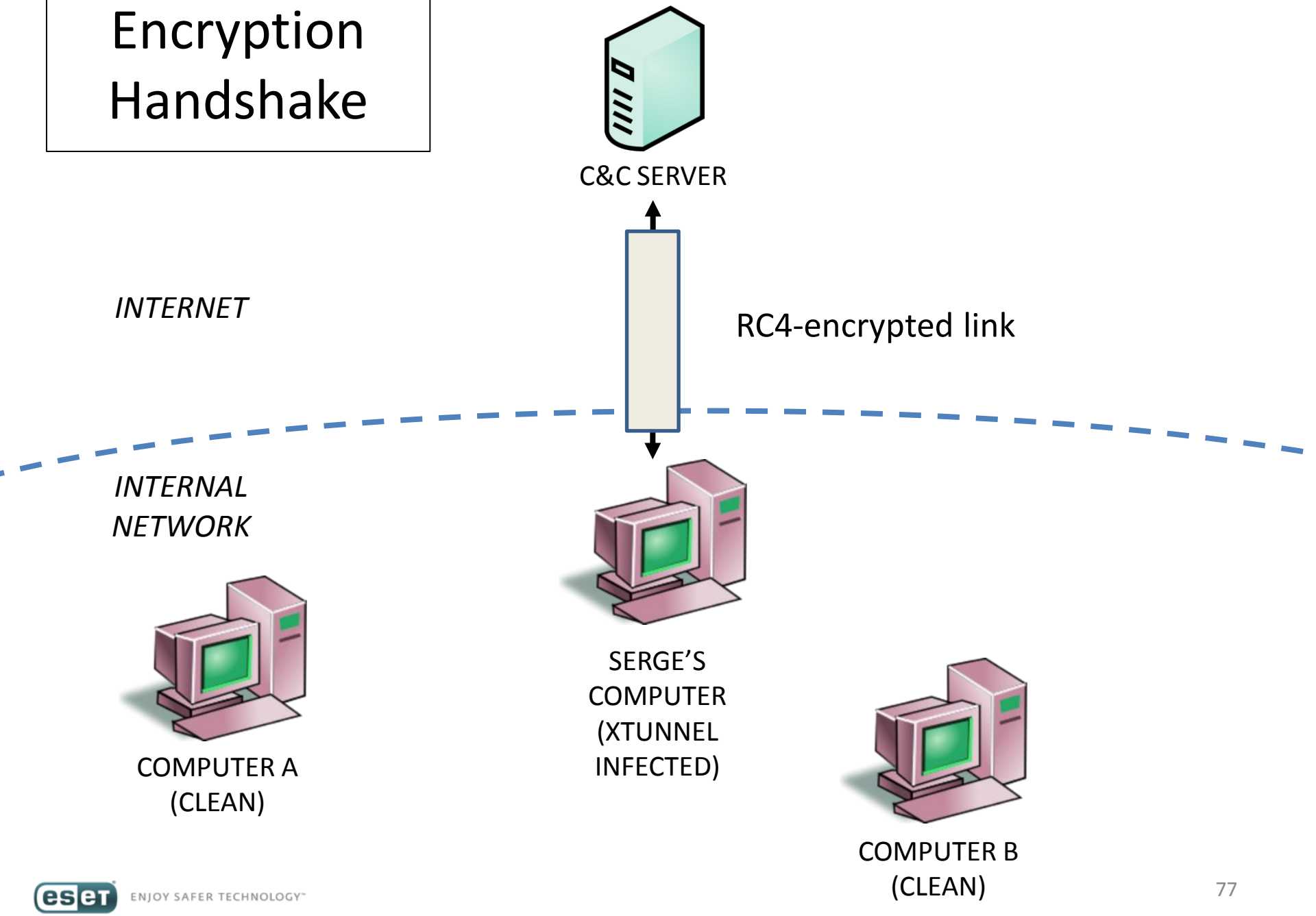
COMPUTER A (CLEAN)

SERGE'S COMPUTER (XTUNNEL INFECTED)



COMPUTER B (CLEAN)

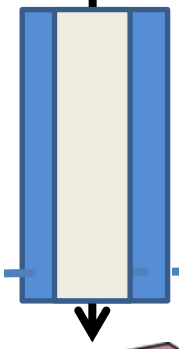
Encryption Handshake



Encryption Handshake

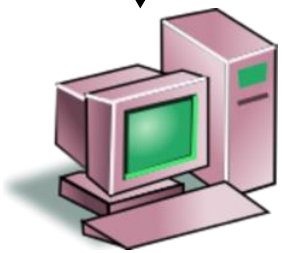
C&C SERVER

INTERNET

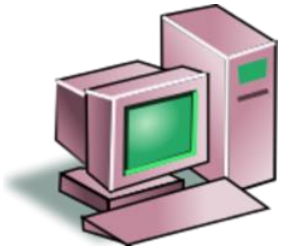


TLS encapsulation
(added in 2014)

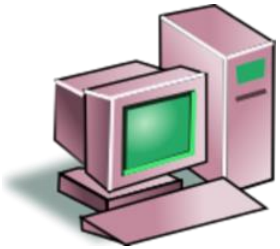
INTERNAL NETWORK



SERGE'S COMPUTER (XTUNNEL INFECTED)

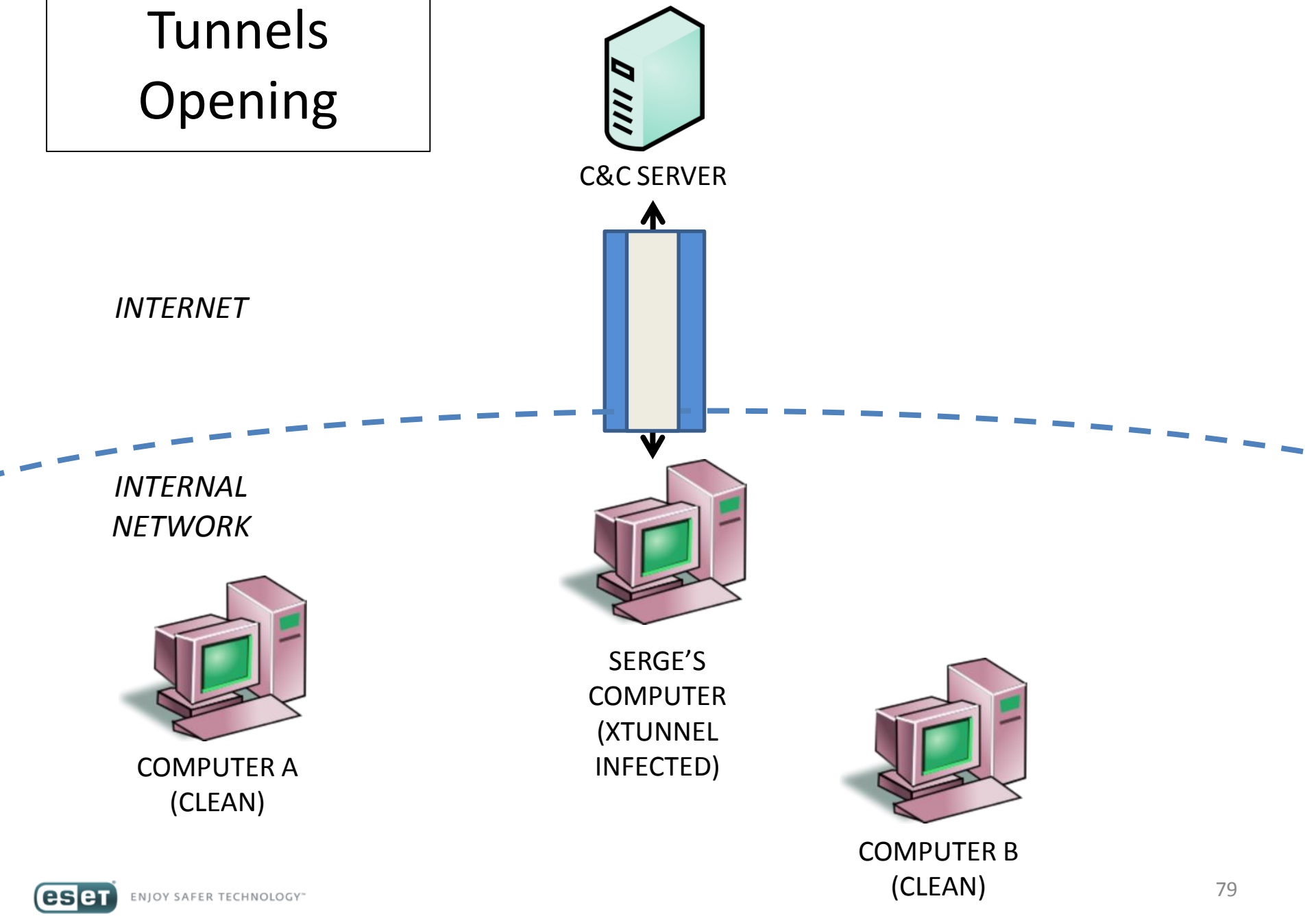


COMPUTER A (CLEAN)

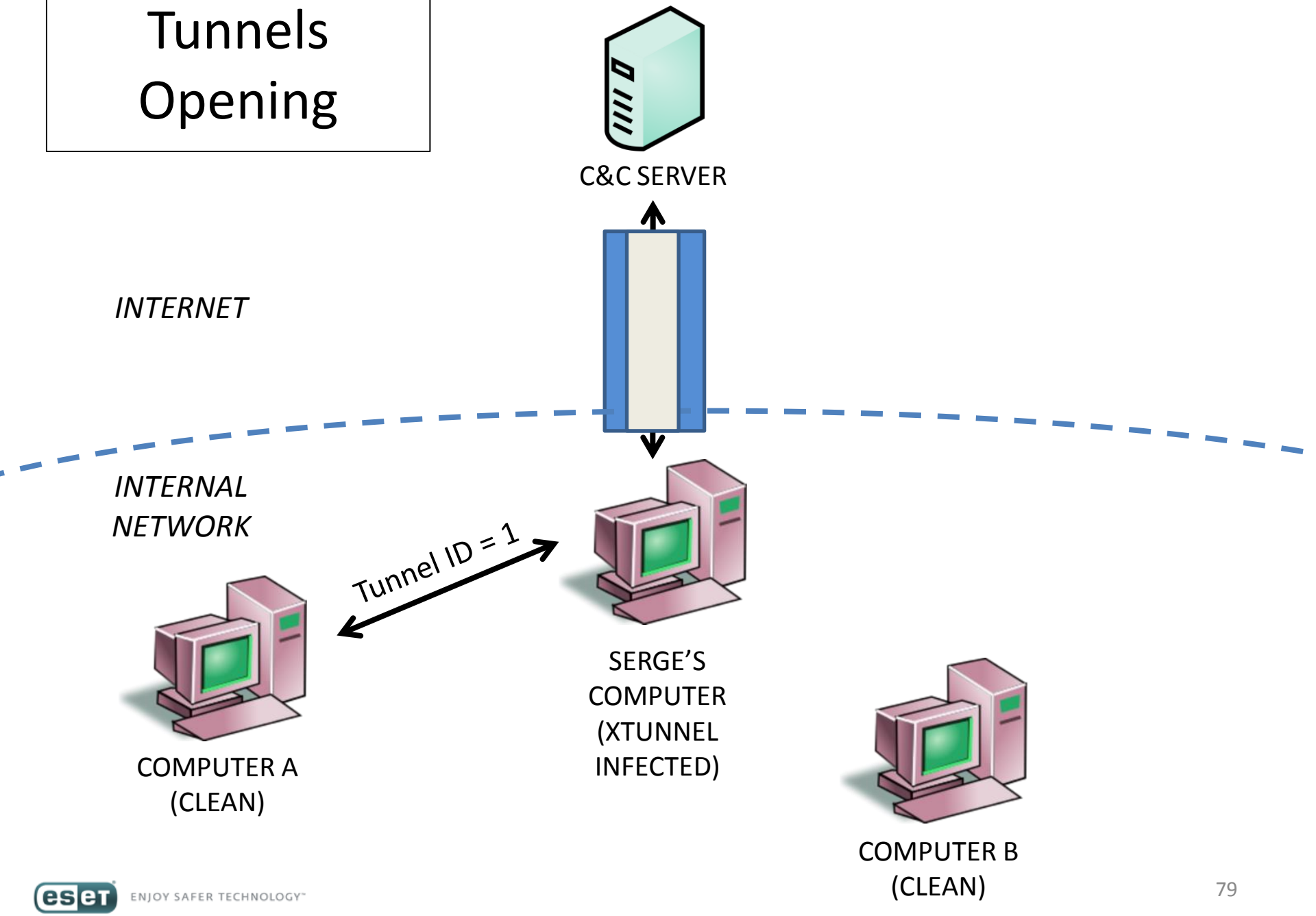


COMPUTER B (CLEAN)

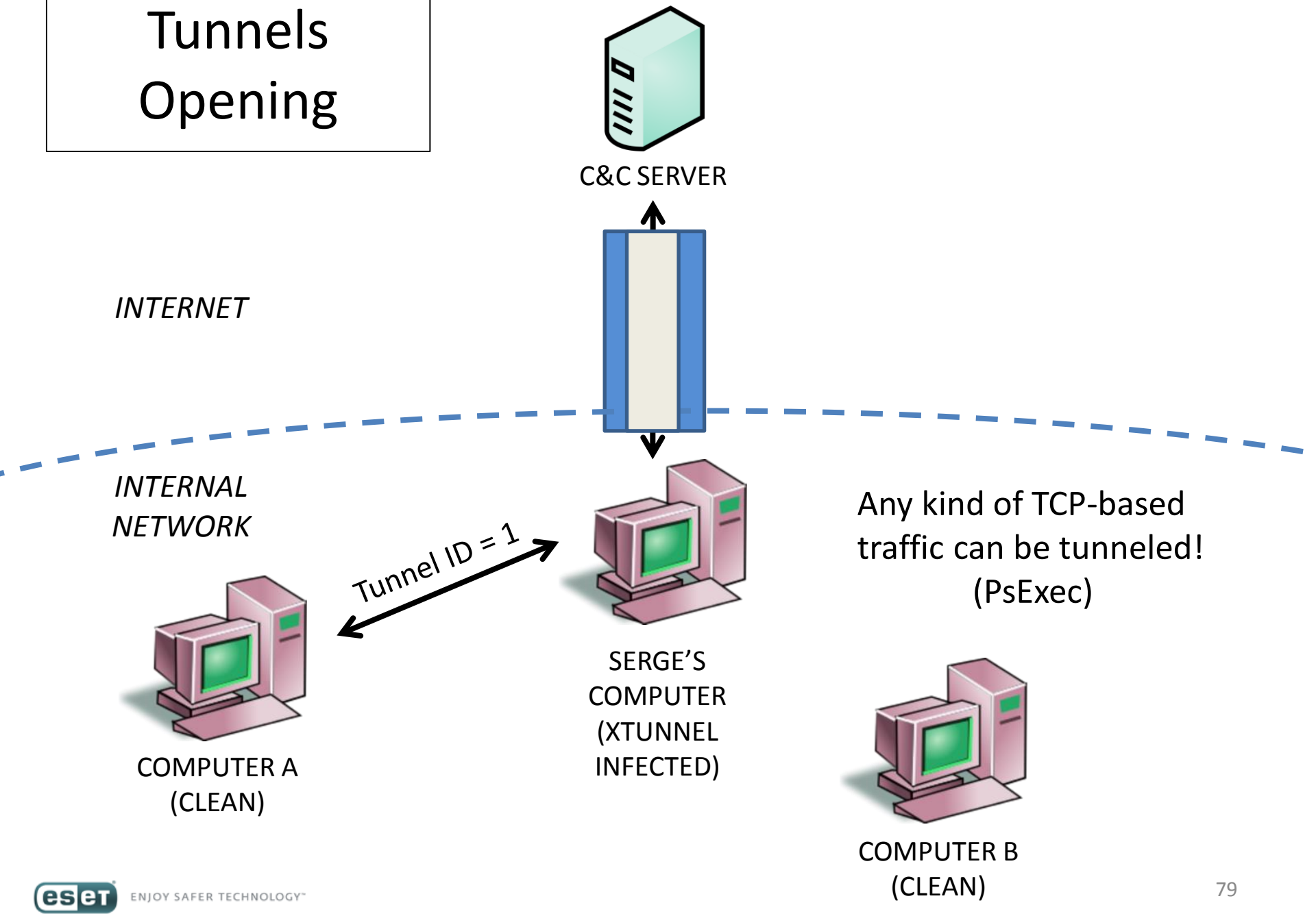
Tunnels Opening



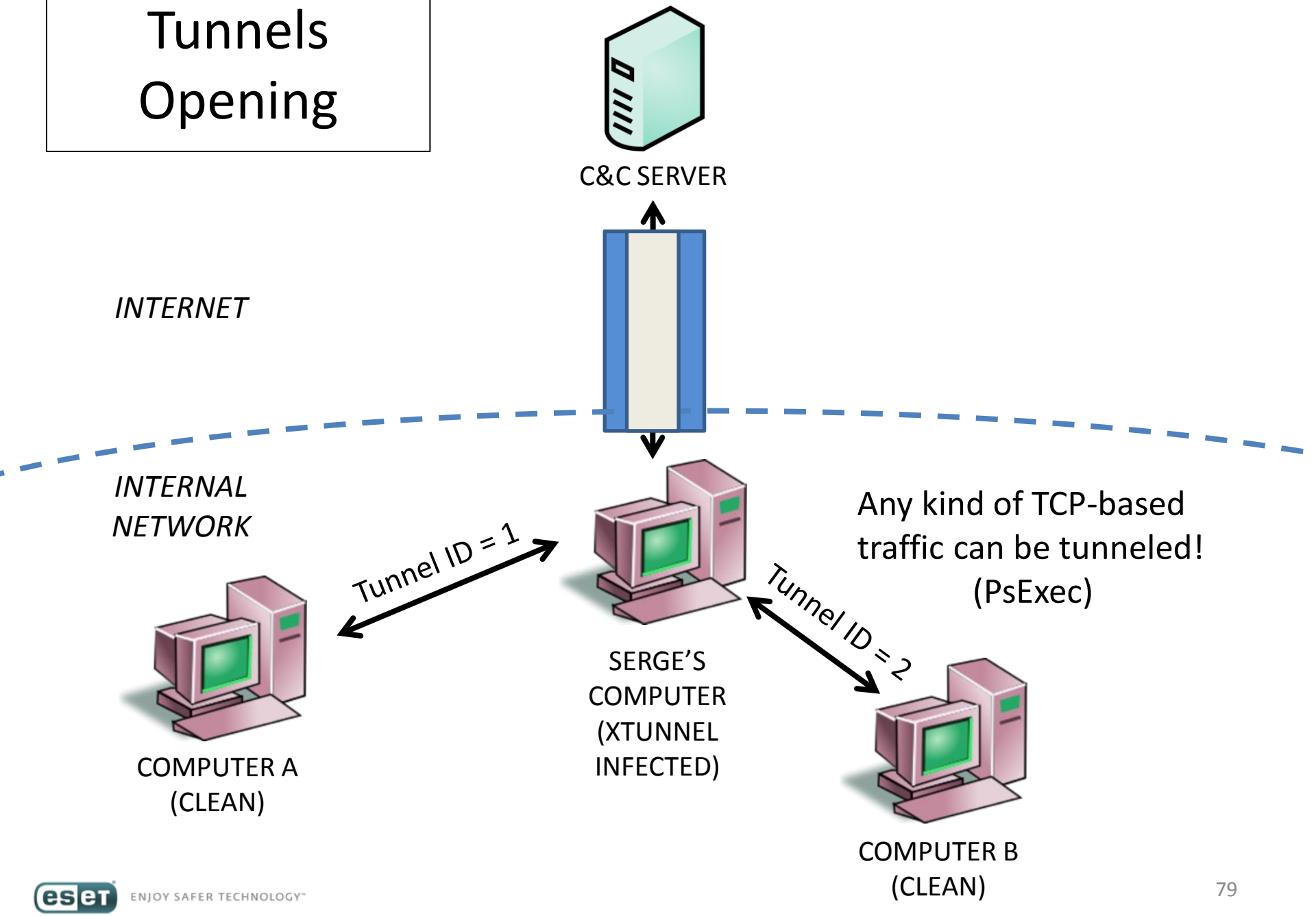
Tunnels Opening



Tunnels Opening



Tunnels Opening



Code Obfuscation (1)

- Starting in July 2015 XTUNNEL code was obfuscated

(which is two months after the Sednit attack against the German parliament, where XTUNNEL was used)

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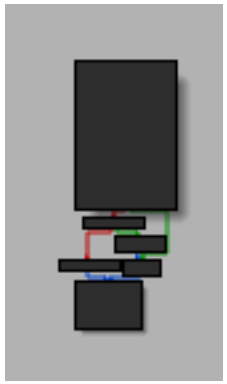
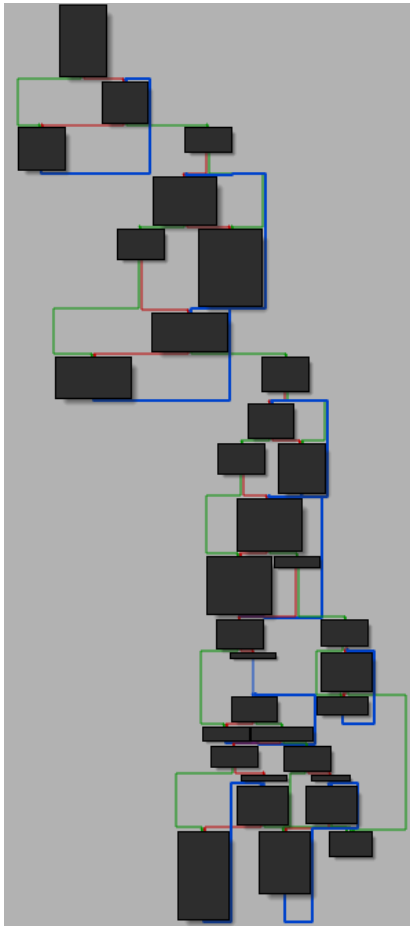
- The obfuscation is a mix of classic syntactic techniques, like insertion of junk code and opaque predicates

Code Obfuscation (2)

BEFORE



AFTER



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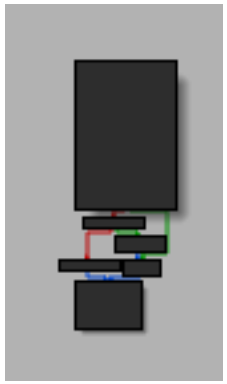
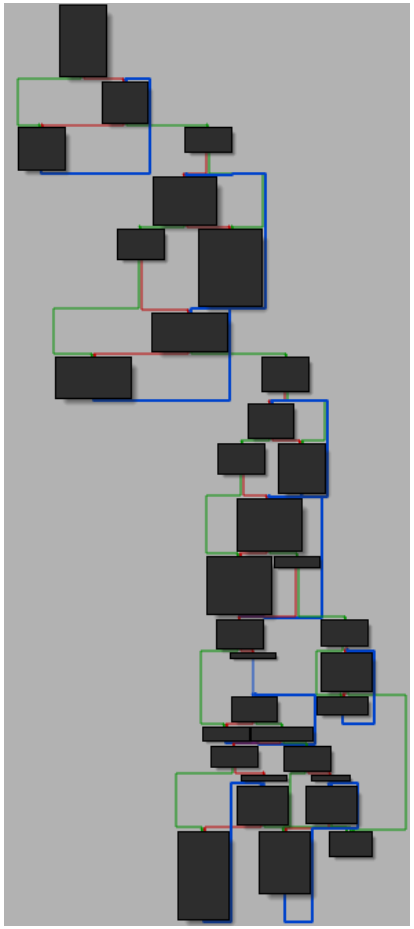
BEFORE

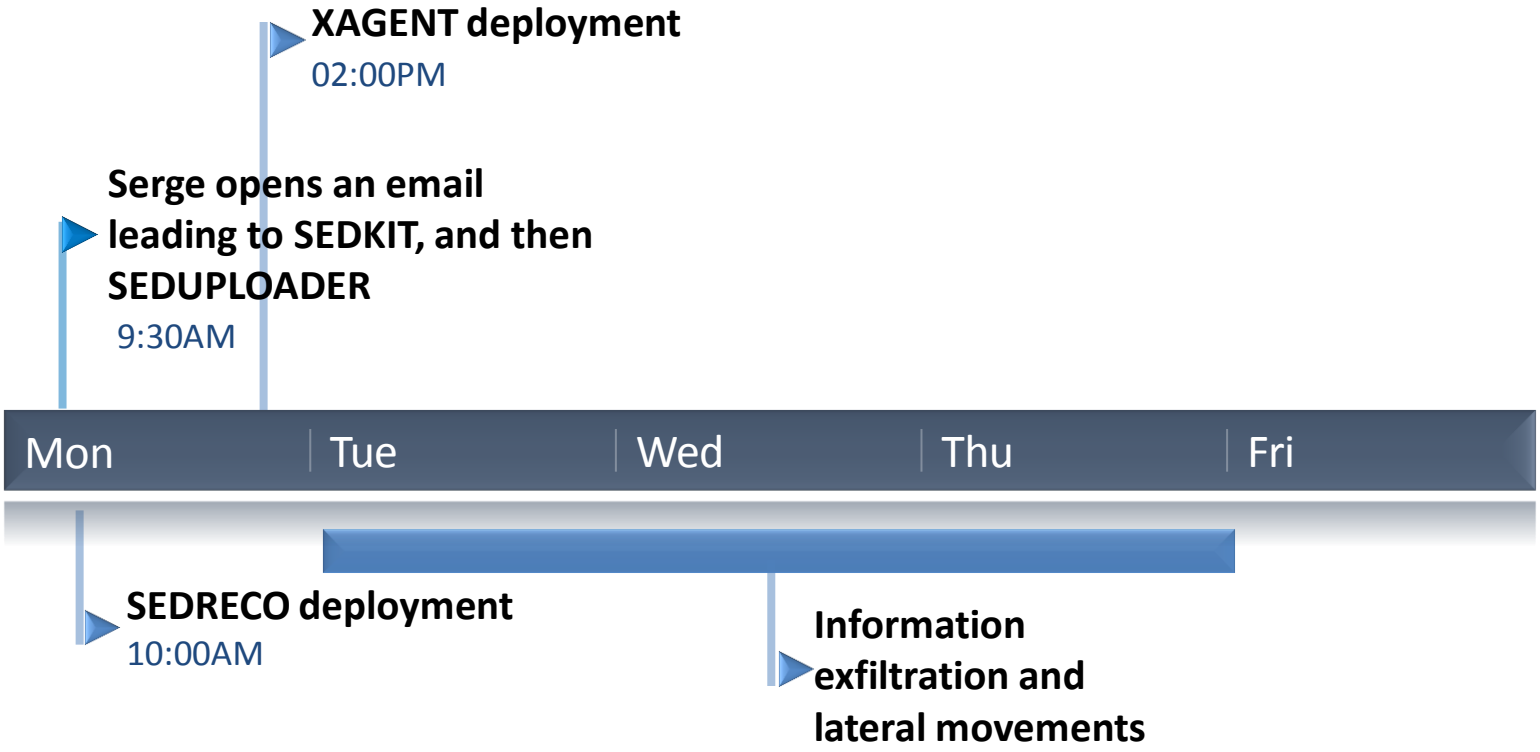


AFTER



Good toy example for automatic desobfuscation magic?

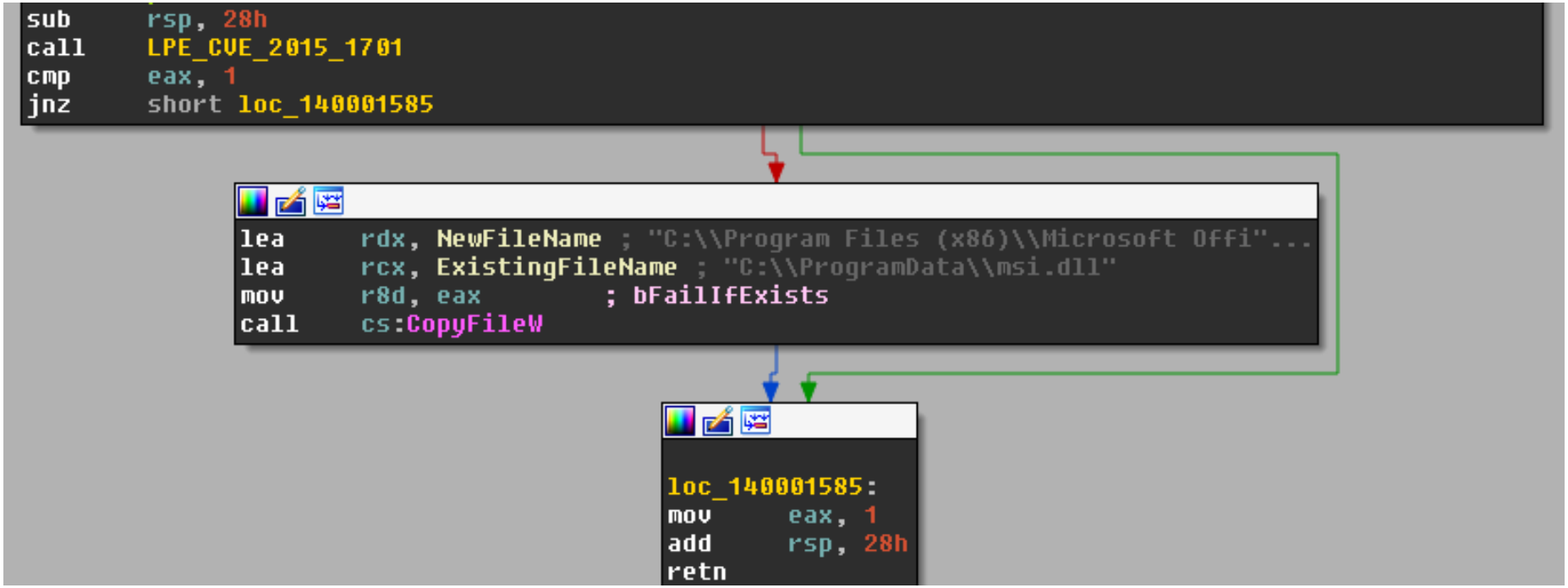
Chain of Events



FRIDAY, 11:00AM

Long Term Persistence (1)

- Special XAGENT copied in Office folder under the name "`msi.dll`"



Long Term Persistence (2)

- `system32\msi.dll` is a legitimate Windows DLL needed by Office applications

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- `system32\msi.dll` is a legitimate Windows DLL needed by Office applications
- XAGENT `msi.dll` exports the same function names as the legitimate `msi.dll`:

```
; Export Address Table for msi.dll
;
off_1002A918    dd rva MsiAdvertiseProductA, rva MsiAdvertiseProductW
                                        ; DATA XREF: .rdata:1002A90C↑o
                dd rva MsiCloseAllHandles, rva MsiCloseHandle, rva MsiCollectUserInfoA
                dd rva MsiCollectUserInfoW, rva MsiConfigureFeatureA, rva MsiConfigureFeature
                dd rva MsiConfigureFeatureFromDescriptorW, rva MsiConfigureFeatureW
                dd rva MsiConfigureProductA, rva MsiConfigureProductW
                dd rva MsiCreateRecord, rva MsiDatabaseApplyTransformA
                dd rva MsiDatabaseApplyTransformW, rva MsiDatabaseCommit
                dd rva MsiDatabaseExportA, rva MsiDatabaseExportW, rva MsiDatabaseGenerateTra
                dd rva MsiDatabaseGenerateTransformW, rva MsiDatabaseGetPrimaryKeysA
                dd rva MsiDatabaseGetPrimaryKeysW, rva MsiDatabaseImportA
```

Long Term Persistence (3)

- Each time Serge starts Office, XAGENT `msi.dll` is loaded (search-order hijacking):
  - Loads real `msi.dll` from system32
  - Fills its export table with the addresses of the real `msi.dll` functions
  - Starts XAGENT malicious logic

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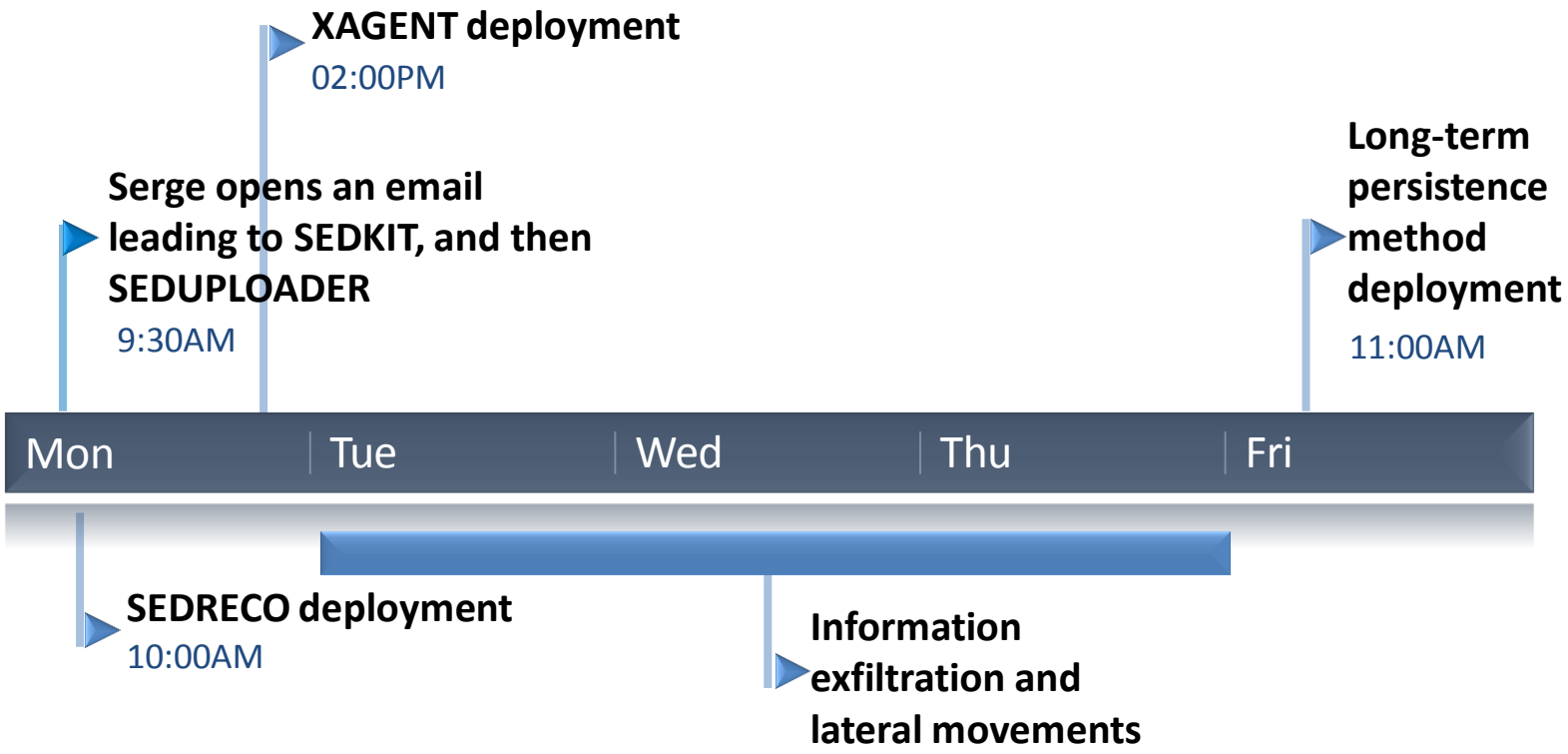
  - Starts XAGENT malicious logic

- Same technique also seen with `LINKINFO.dll` dropped in `C:\WINDOWS`

Chain of Events



What the hell is going on here ?!

THE MYSTERIOUS DOWNDELPH

Discovery

September 2015

- Classic Sednit dropper
- Shows a decoy document

FRIEDRICH EBERT STIFTUNG

SFPA
Slovak Foreign Policy Association

MINISTRY OF FOREIGN AND EUROPEAN AFFAIRS OF THE SLOVAK REPUBLIC

Conference	**EU Eastern Policy: shaping relations with Russia and Ukraine**
Date	3 November 2015
Venue	Congress Hall of the Ministry of Foreign and European Affairs of the Slovak Republic, Hlboká cesta 2, Bratislava
Organizer	Research Center of the Slovak Foreign Policy Association
Partners	Friedrich Ebert Stiftung and the Ministry of Foreign and European Affairs of the Slovak Republic
Media partner	EurActiv.sk
Working language	English
Aim	The aim of the conference is to discuss EU policy towards Eastern Europe with focus on topical issues that frame its current agenda with Russia and Ukraine. The one-day conference will, first, examine prospects for further

What Is In This Dropper?

The Ultimate Boring Component

- Delphi downloader, we named it DOWNDELPH (slow clap)
- Simple workflow:
  - Downloads a config (.INI file)
  - Based on the config, downloads a payload
  - Executes payload
- Persistence method: Run registry key

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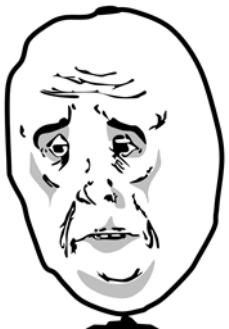
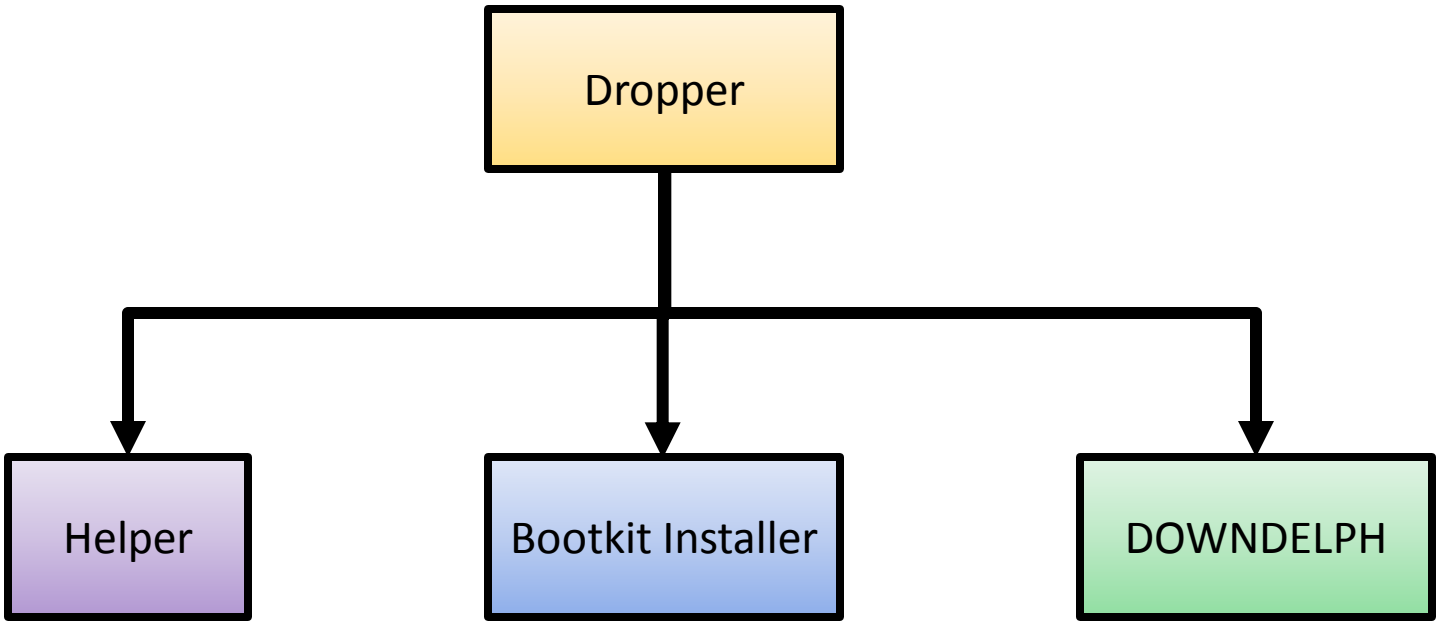


Let The Hunt Begins

2013 DOWNDELPH Sample



Let The Hunt Begins

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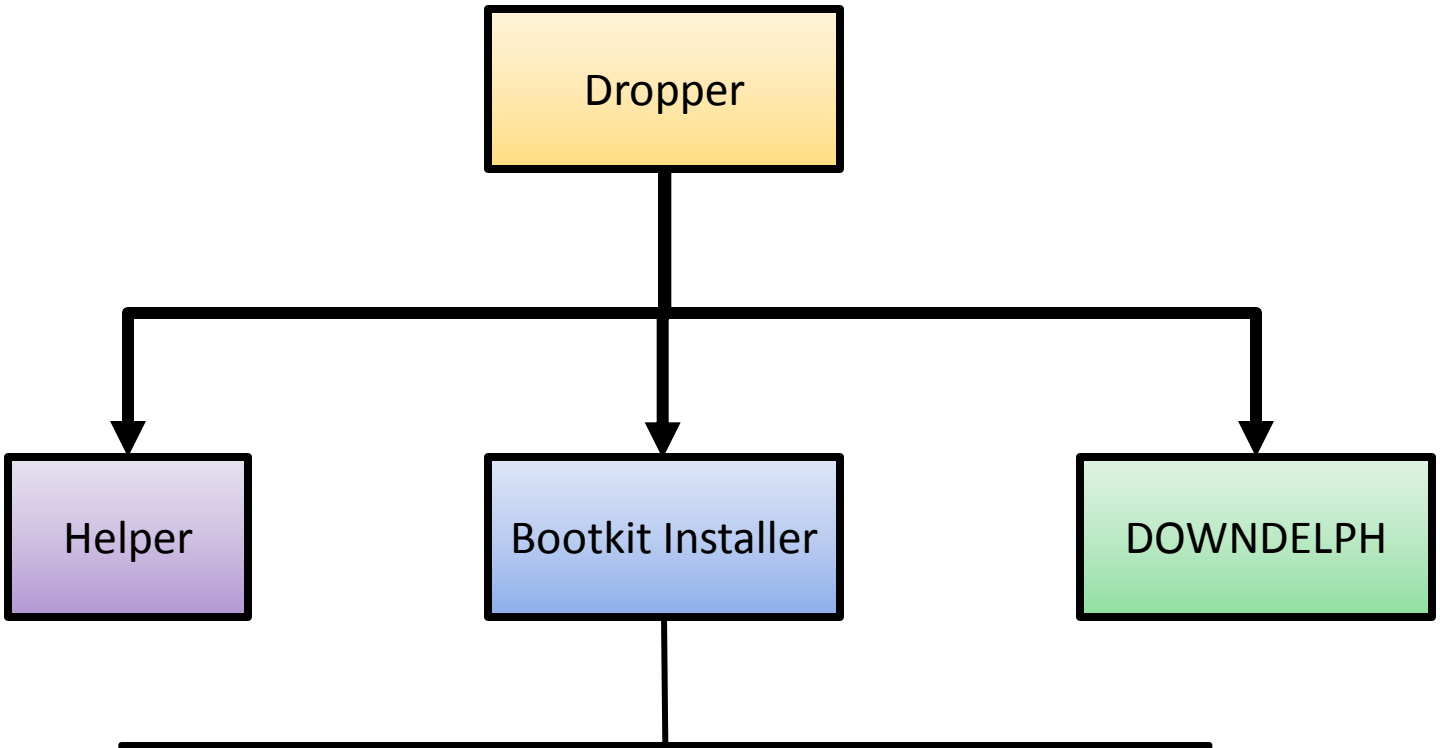
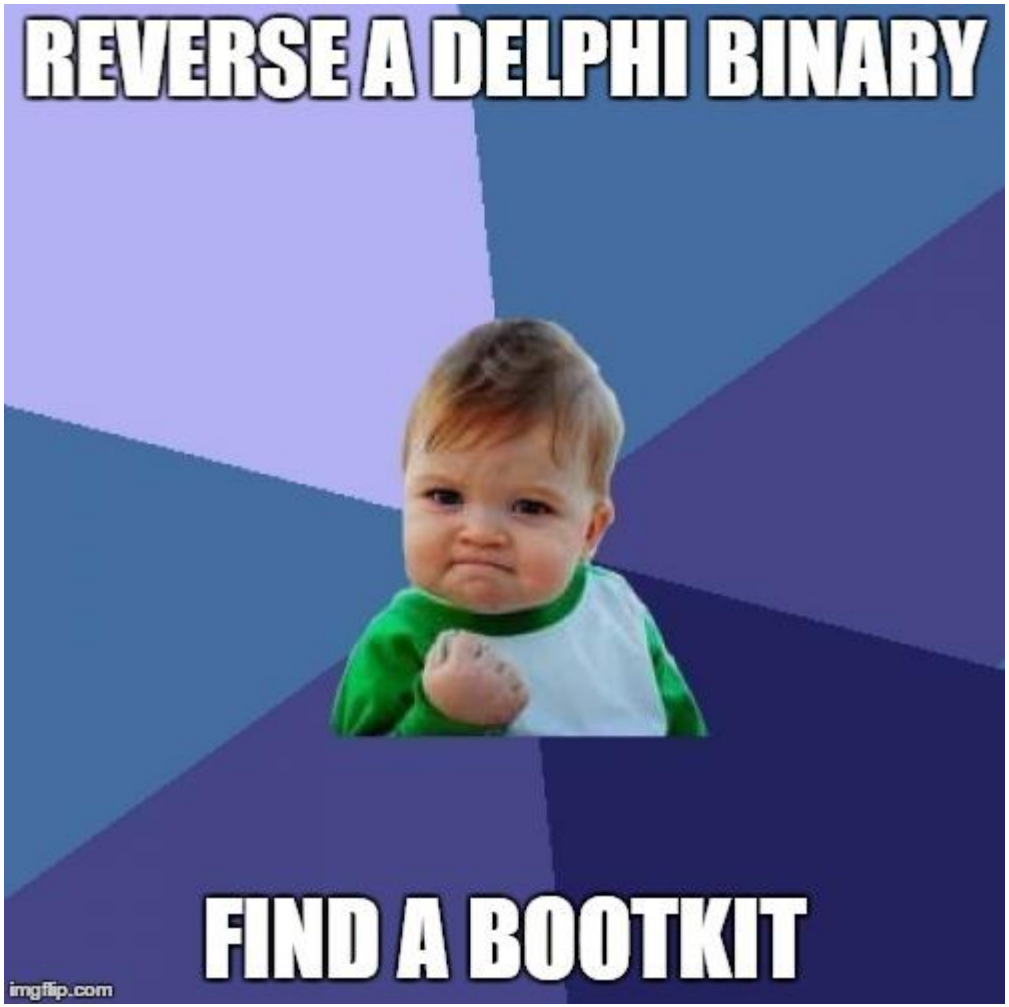


- Infects BIOS-based systems
- Tested on Windows XP/7, 32bit/64bit
- Never been documented

Not So Boring Component



Bootkit Installation

1ST sector

MBR	Legitimate data

First sectors before infection

Bootkit Installation

1ST sector 2ND sector

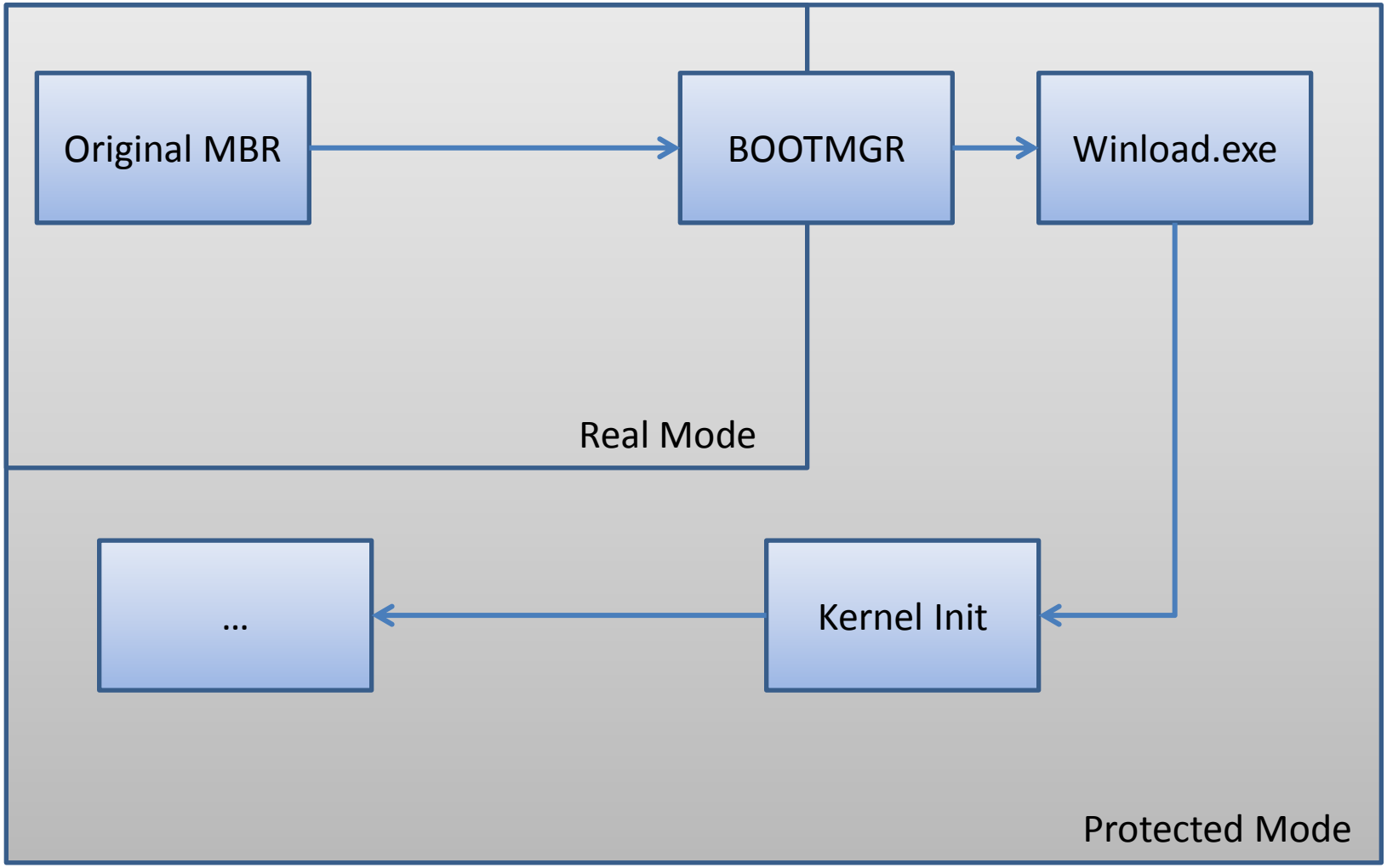
Malicious MBR	Original MBR (1-byte XOR)	Hooks (1-byte XOR)	Driver (1-byte XOR + RC4)	Legitimate Data

First sectors before infection

First sectors after infection

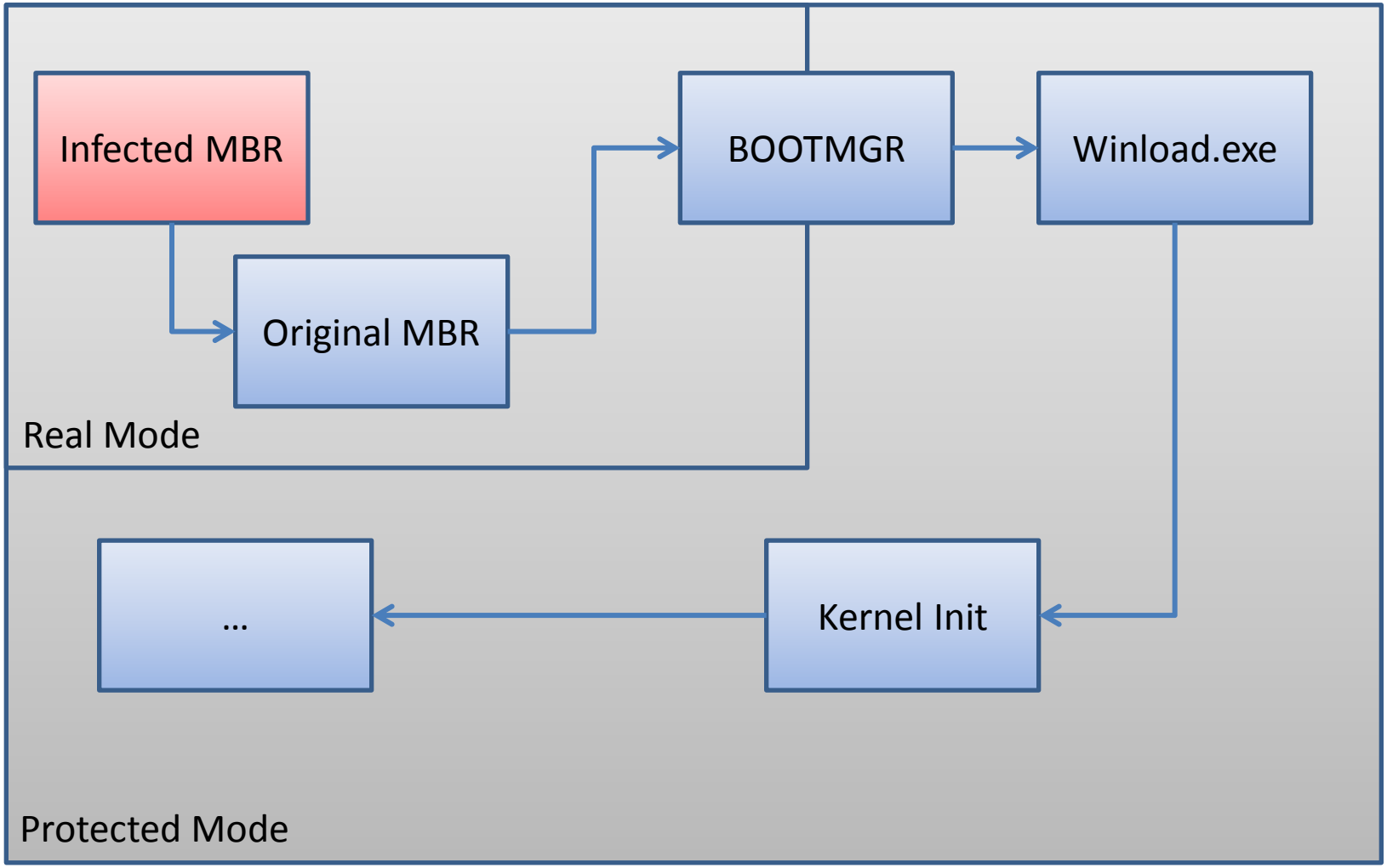
Normal Boot Process

Windows 7 x64



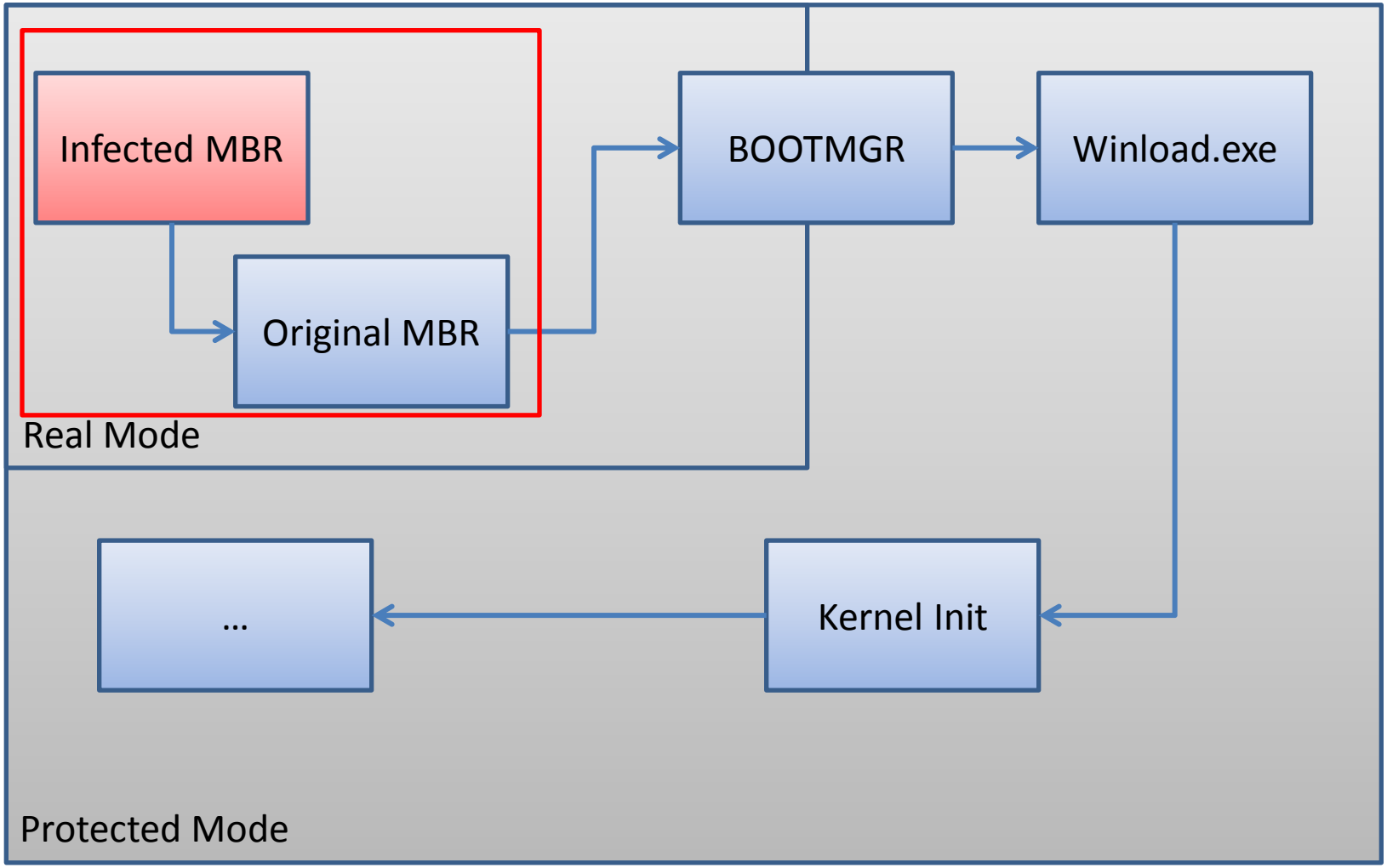
Infected Boot Process

Windows 7 x64



Infected Boot Process

Windows 7 x64



Malicious MBR

- Hooks INT 13h handler (low-level read/write operations)

```
mov     eax, [bx+4Ch]
mov     es:dword_9A, eax
mov     word ptr [bx+4Ch], offset int13_hook
mov     word ptr [bx+4Eh], es
```

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mov     eax, [bx+4Ch]
mov     es:dword_9A, eax
mov     word ptr [bx+4Ch], offset int13_hook
mov     word ptr [bx+4Eh], es
```
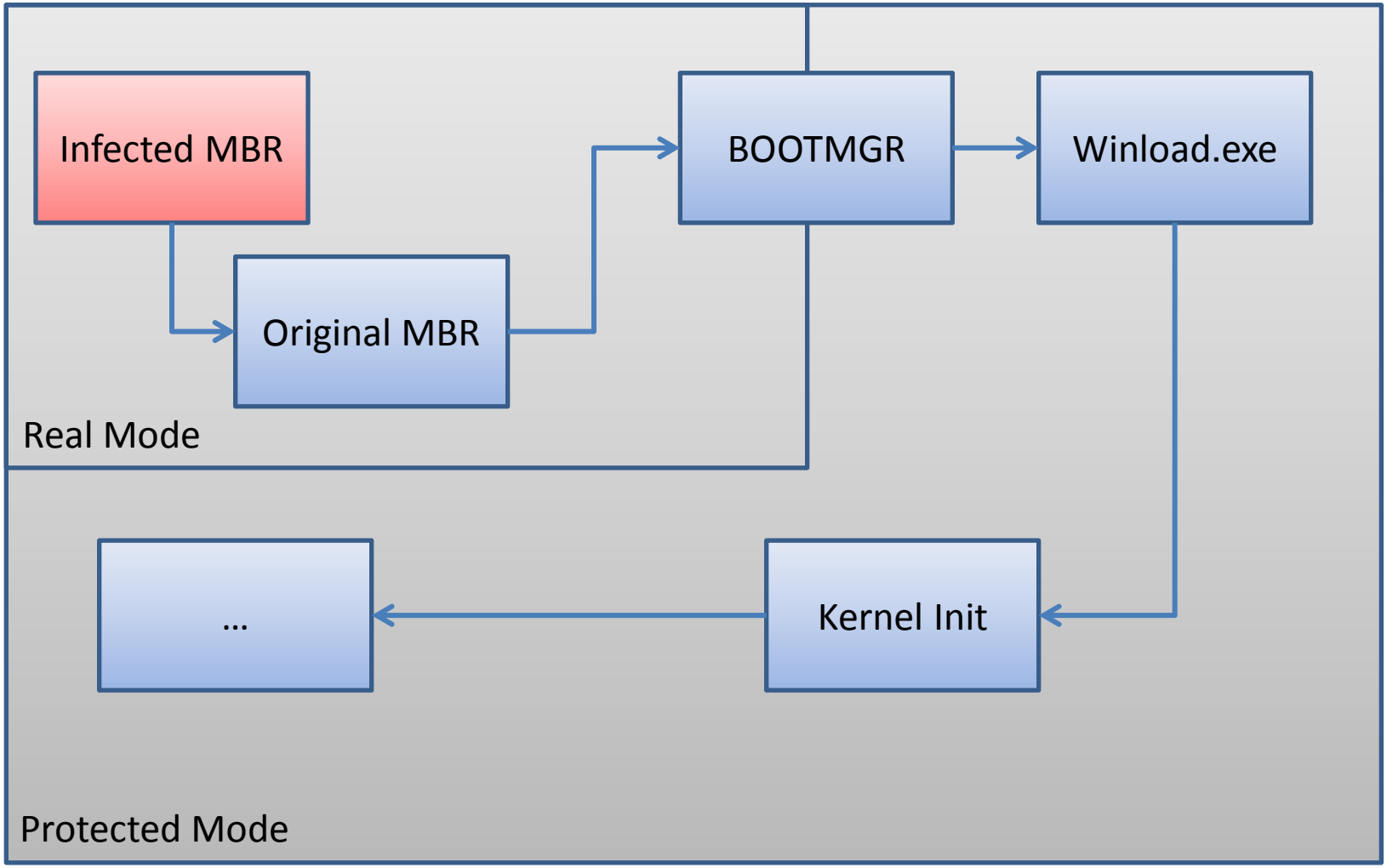

- Patches **BOOTMGR** in memory

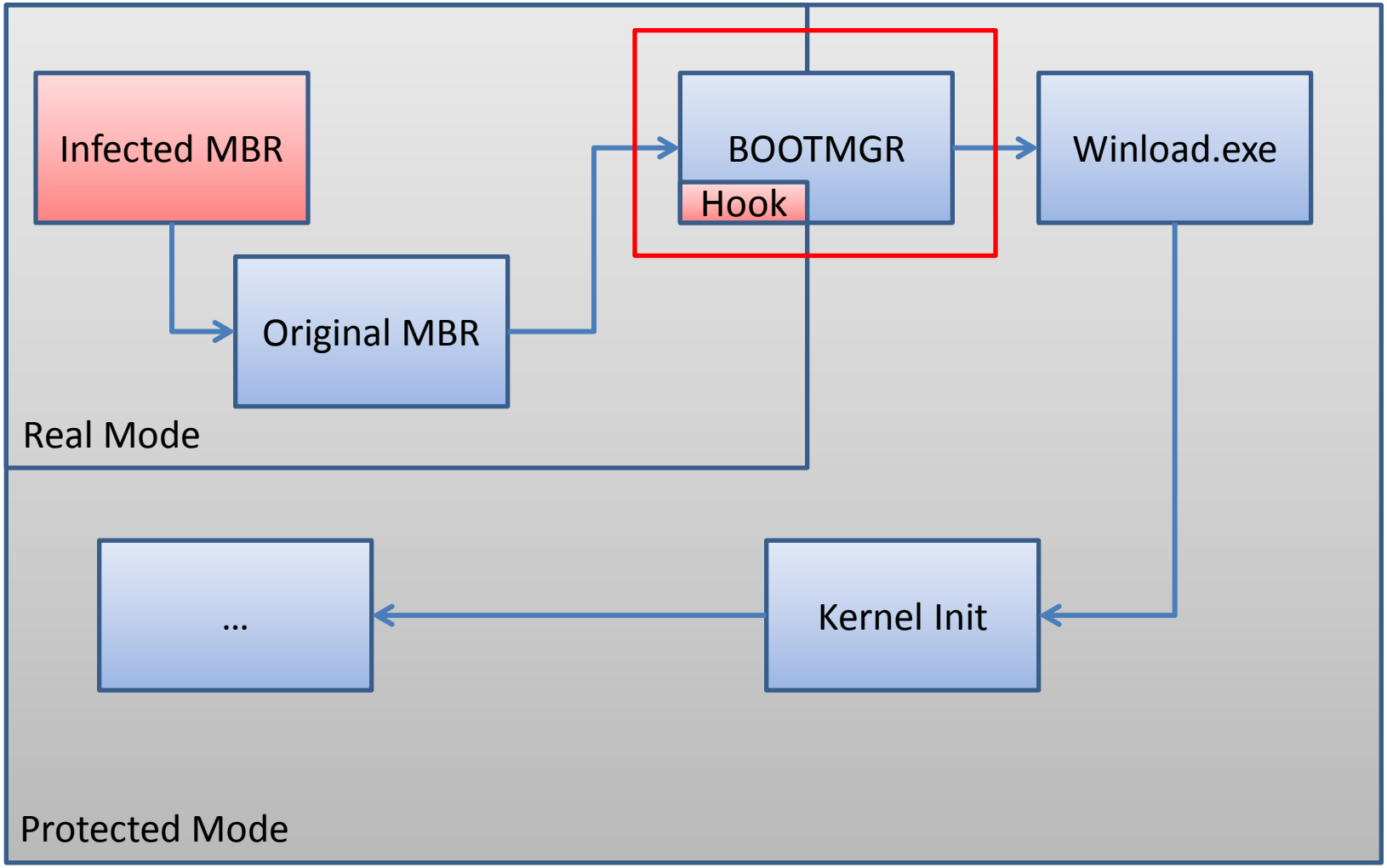
```
find_pattern_1:

repne scasb
jnz     short loc_97D1C
cmp     dword ptr es:[di], 245C8B66h
jnz     short find_pattern_1
cmp     dword ptr es:[di+4], 0C0336602h
jnz     short find_pattern_1
cmp     dword ptr es:[di+0Bh], 8E0010B9h
jnz     short find_pattern_1
```

```
find_pattern_2:

repne scasb
jnz     short find_pattern_loop_end
cmp     dword ptr es:[di], 66000000h
jnz     short find_pattern_2
cmp     dword ptr es:[di+4], 66045E8Bh
jnz     short find_pattern_2
cmp     dword ptr es:[di+8], 6608568Bh
jnz     short find_pattern_2
cmp     word ptr es:[di+0Ch], 0C933h
jnz     short find_pattern_2
```

Bootkit Workflow



Bootkit Workflow



BOOTMGR Hook

- Searches *OslArchTransferToKernel()* in **winload.exe** to patch it

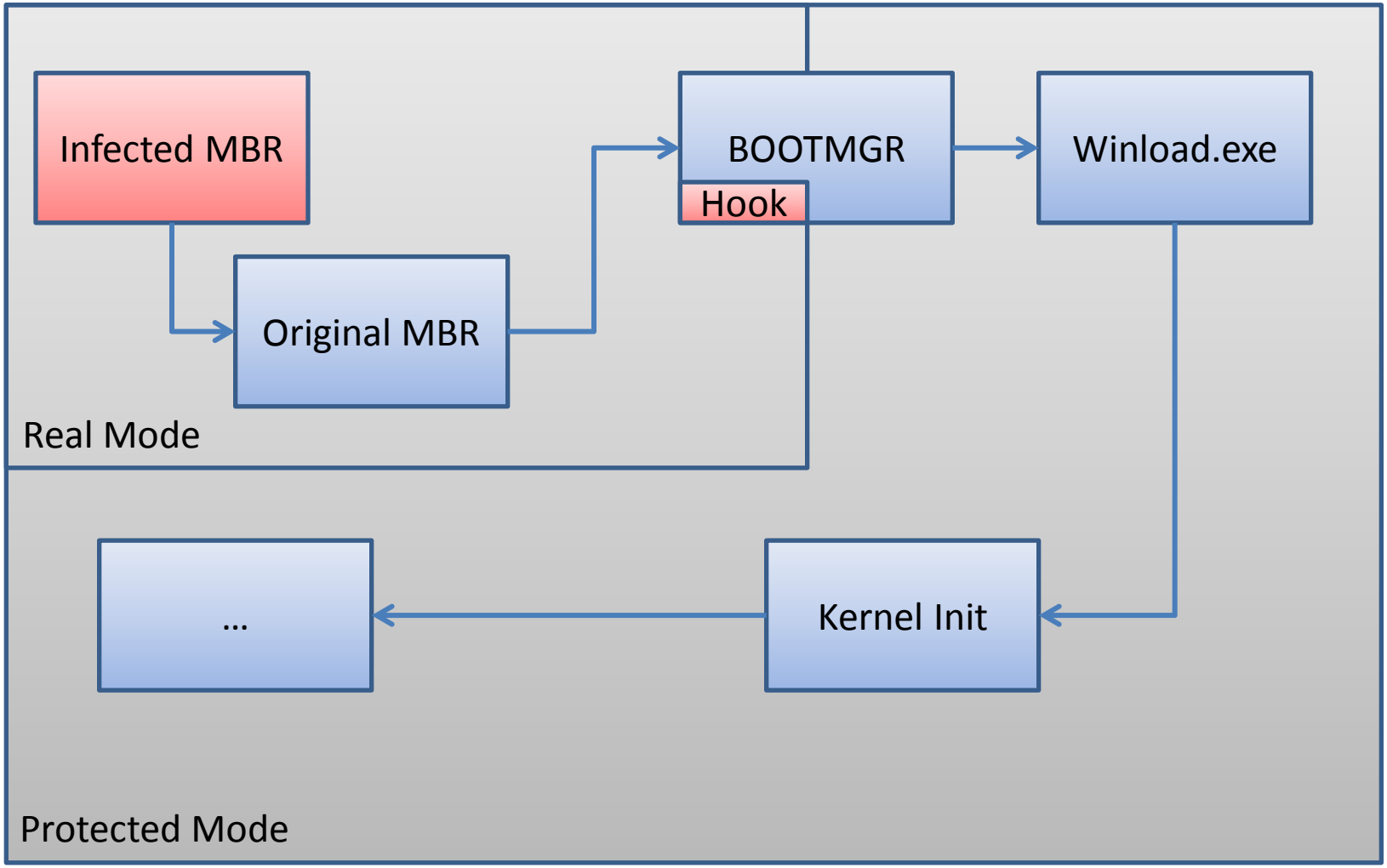
Before:

```
_OslArchTransferToKernel@8 proc far

arg_0           = dword ptr  8

                lgdt    fword ptr _OslKernelGdt
                lidt    fword ptr _OslKernelIdt
```

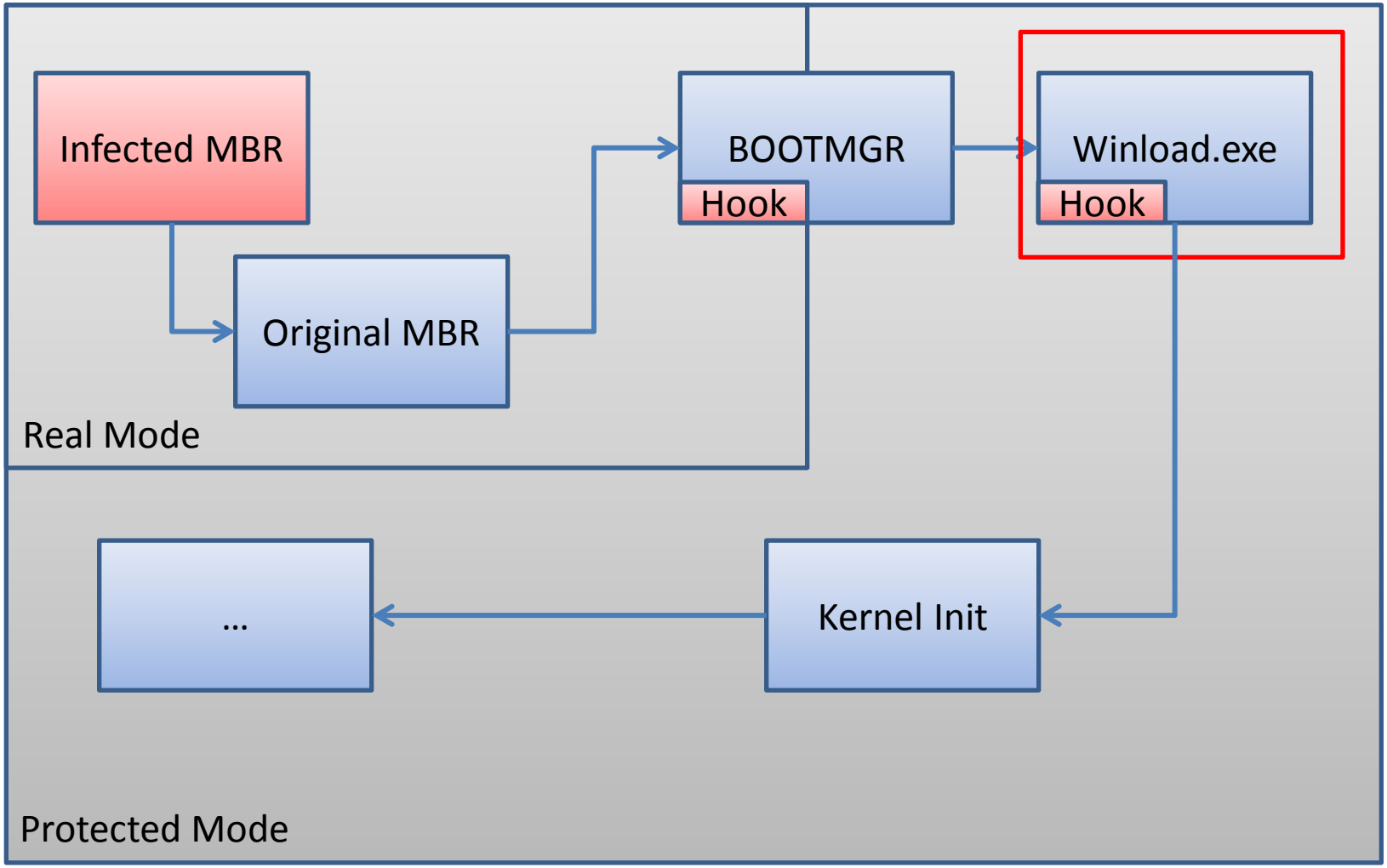
After:

```
kd> u winload!OslArchTransferToKernel
winload!OslArchTransferToKernel:
00000000`003381f0 e961fdd5ff      jmp     00000000`00097f56
```

Bootkit Workflow



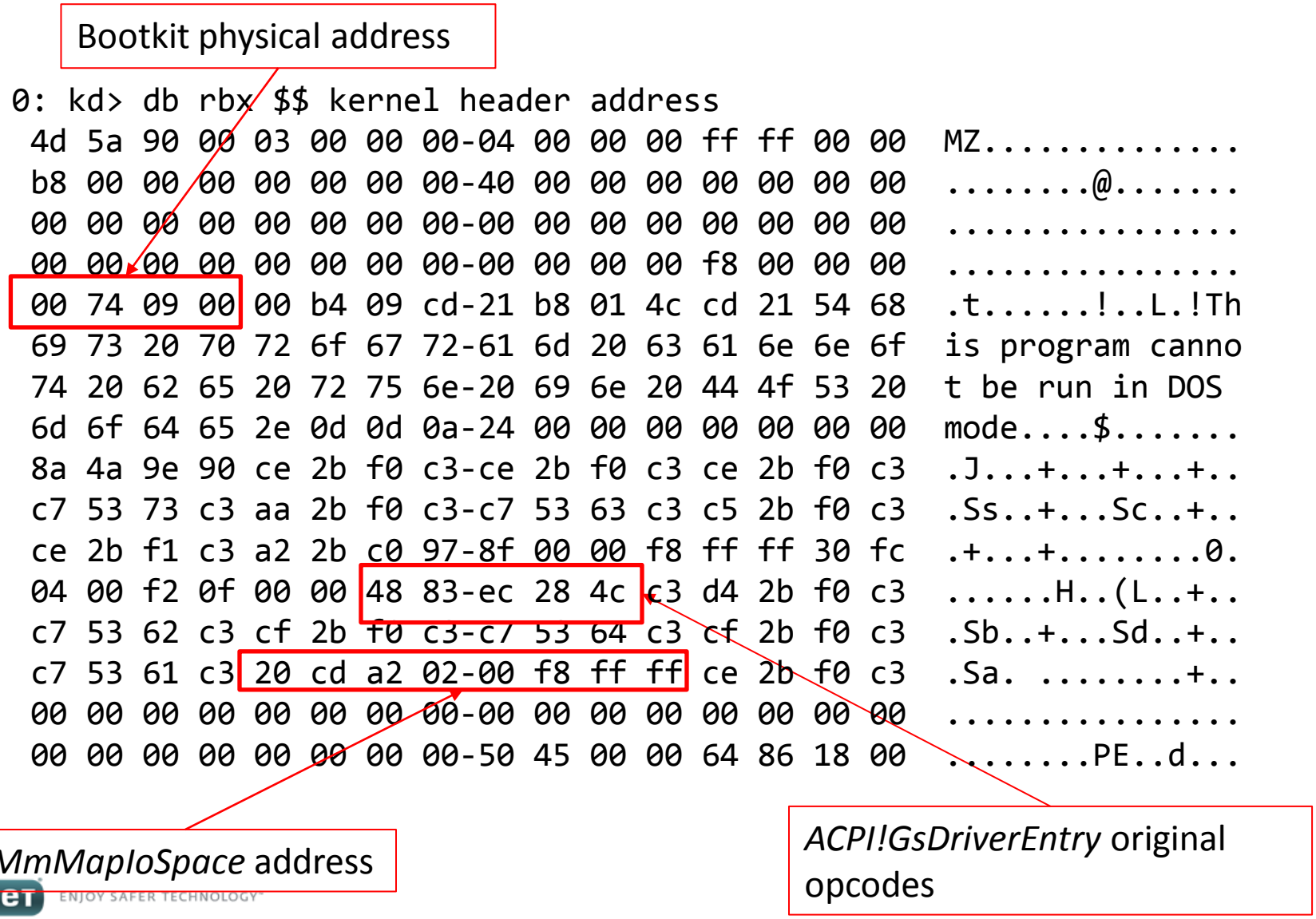
Bootkit Workflow



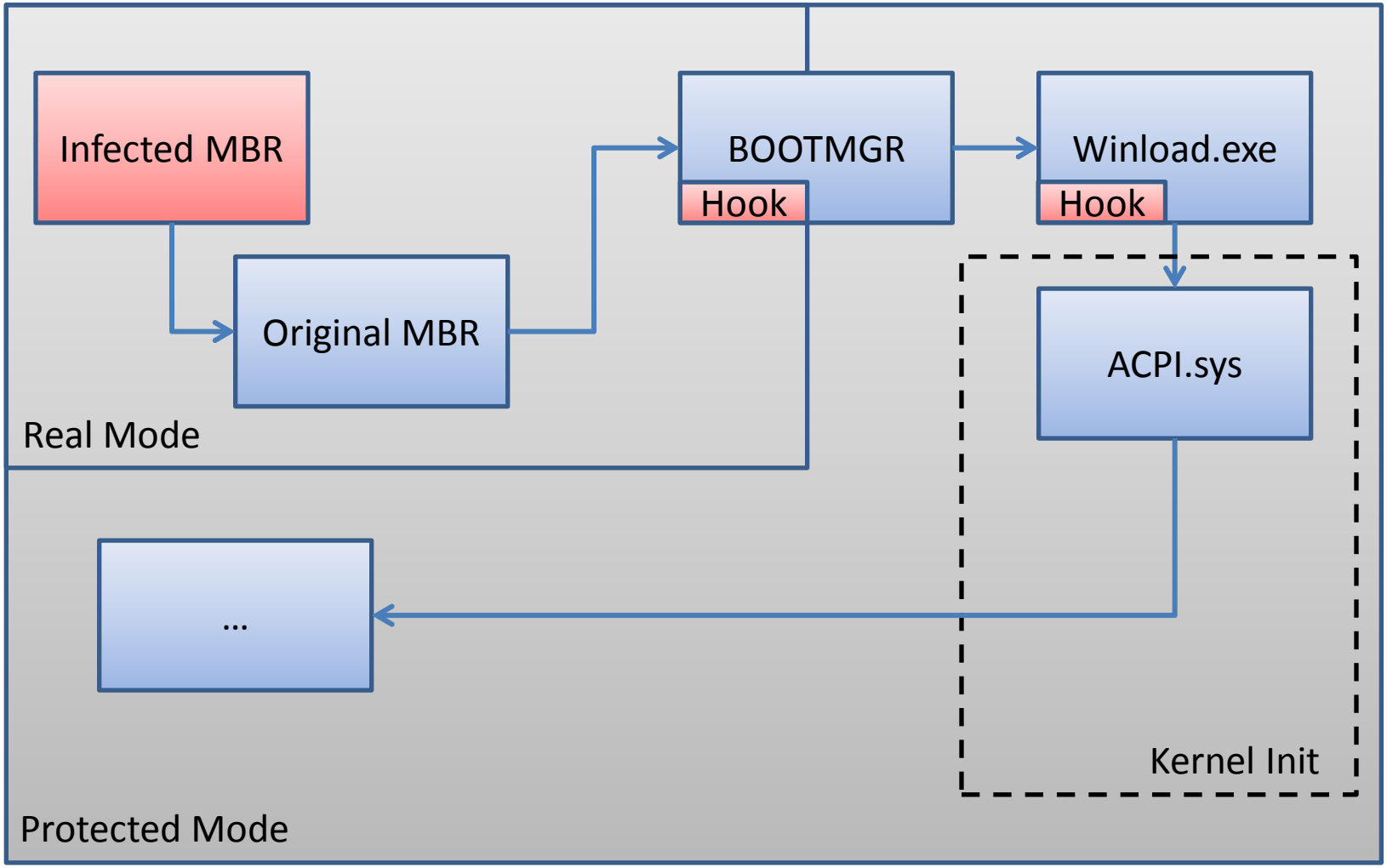
Winload.exe Hook

- Locates *MmMapIoSpace*
- Saves some code in ACPI.sys resources section
  (and makes the section executable)
- Hooks *ACPI!GsDriverEntry*

Saving Important Information



Bootkit Workflow



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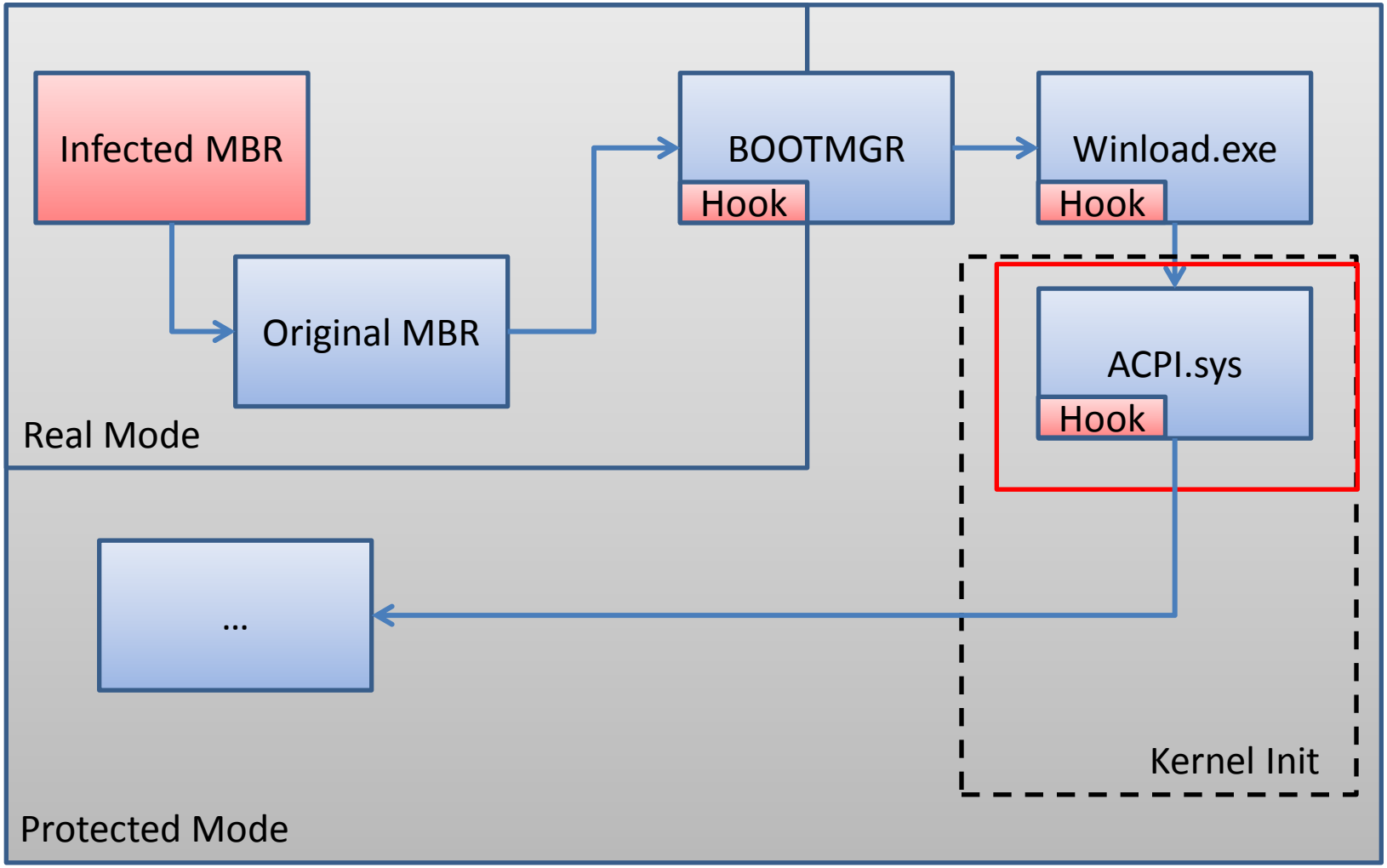
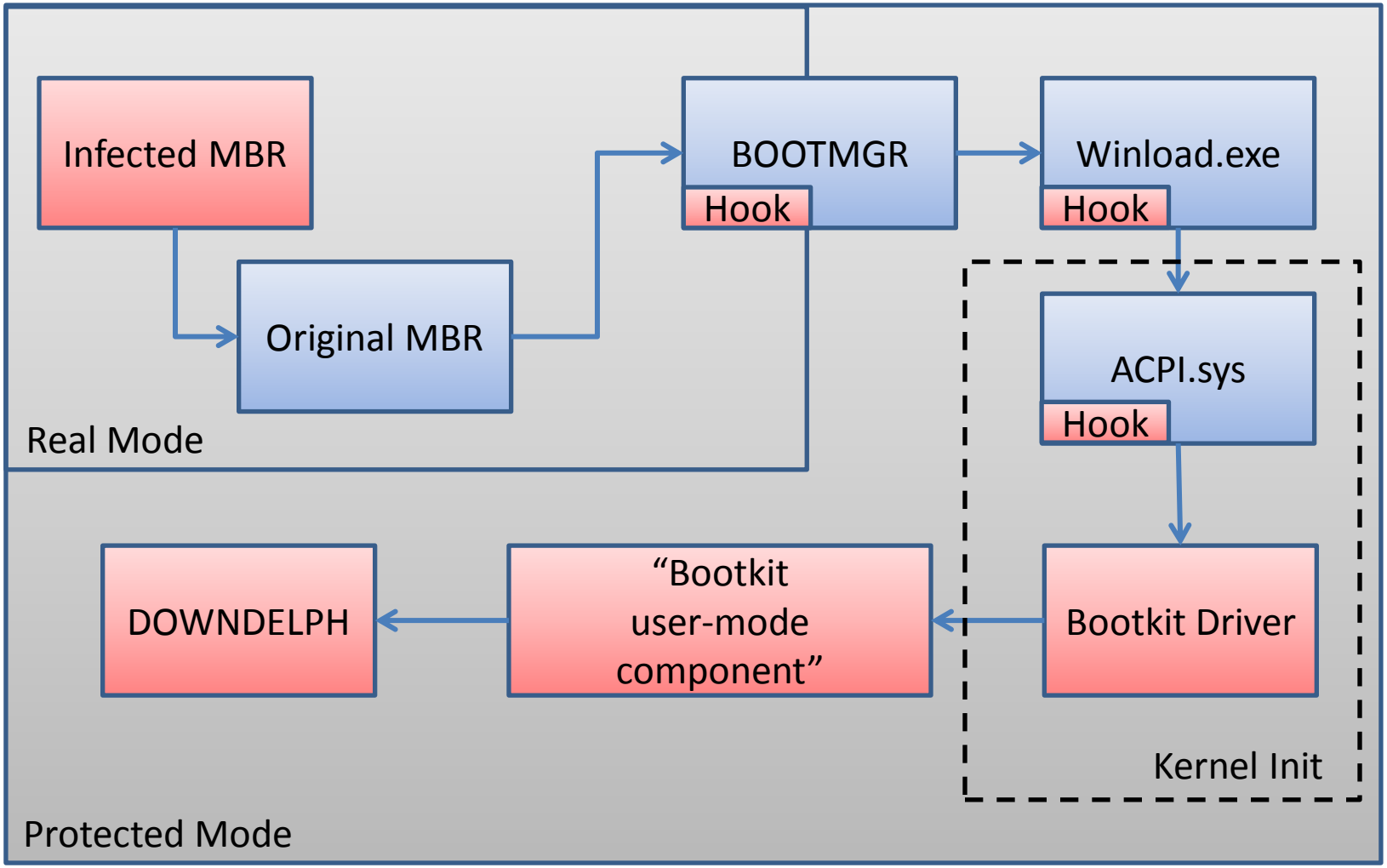


ACPI.sys Hook

- Restores *ACPI!GsDriverEntry*
- Maps the bootkit physical address into virtual address space by calling *MmMapIoSpace*
- Decrypts hidden driver

Bootkit Workflow



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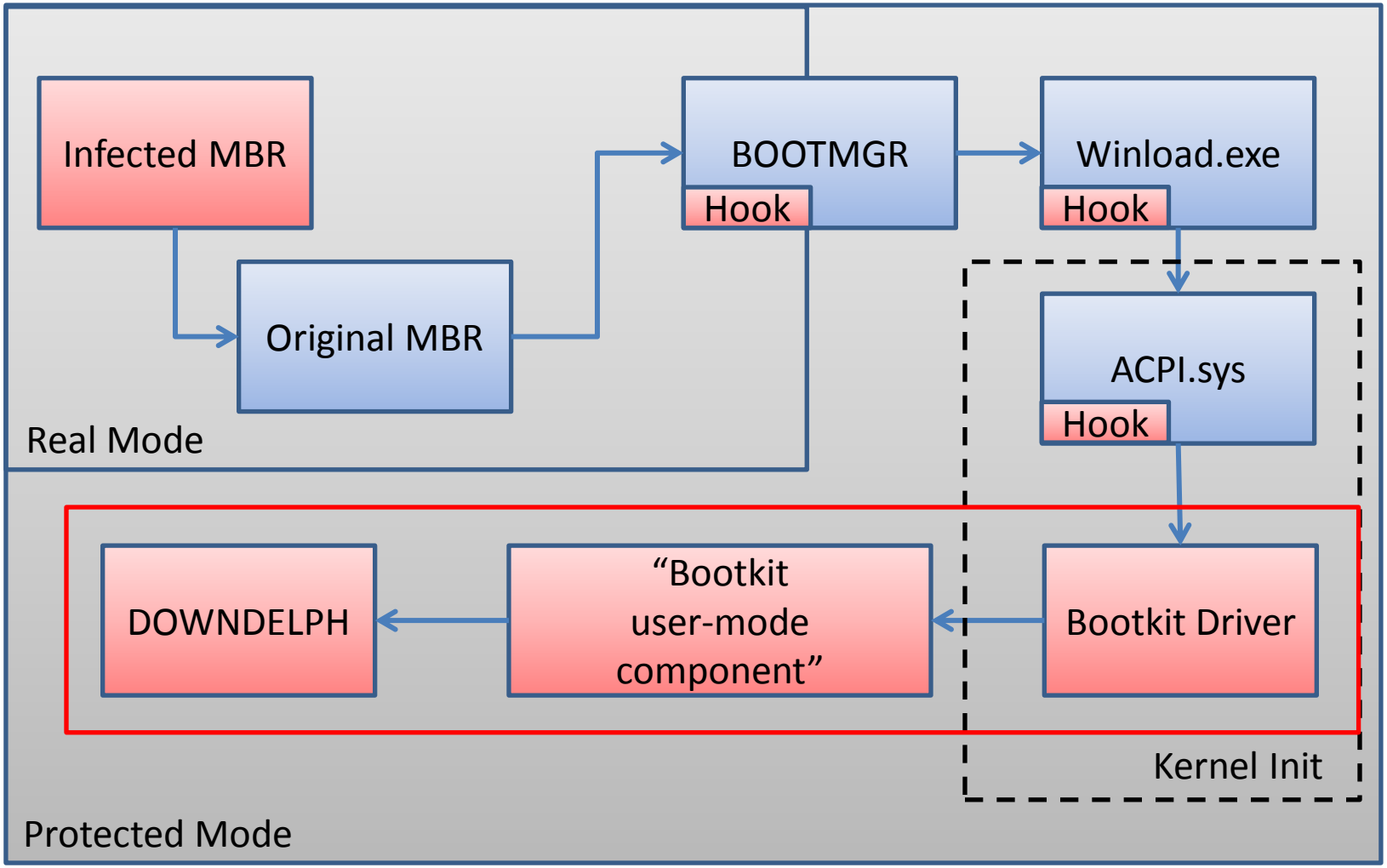

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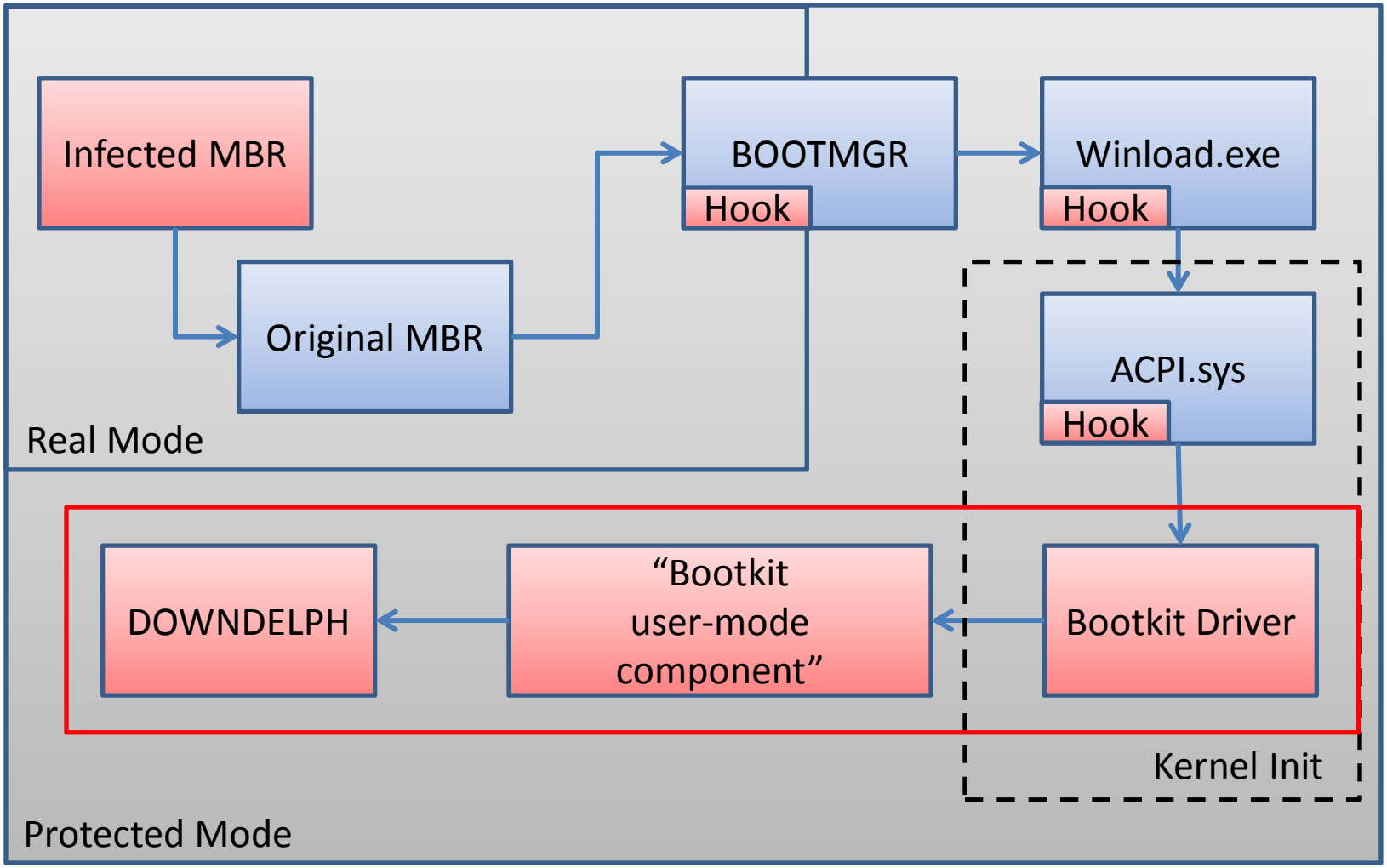

'User mode component of the bootkit has been injected.'

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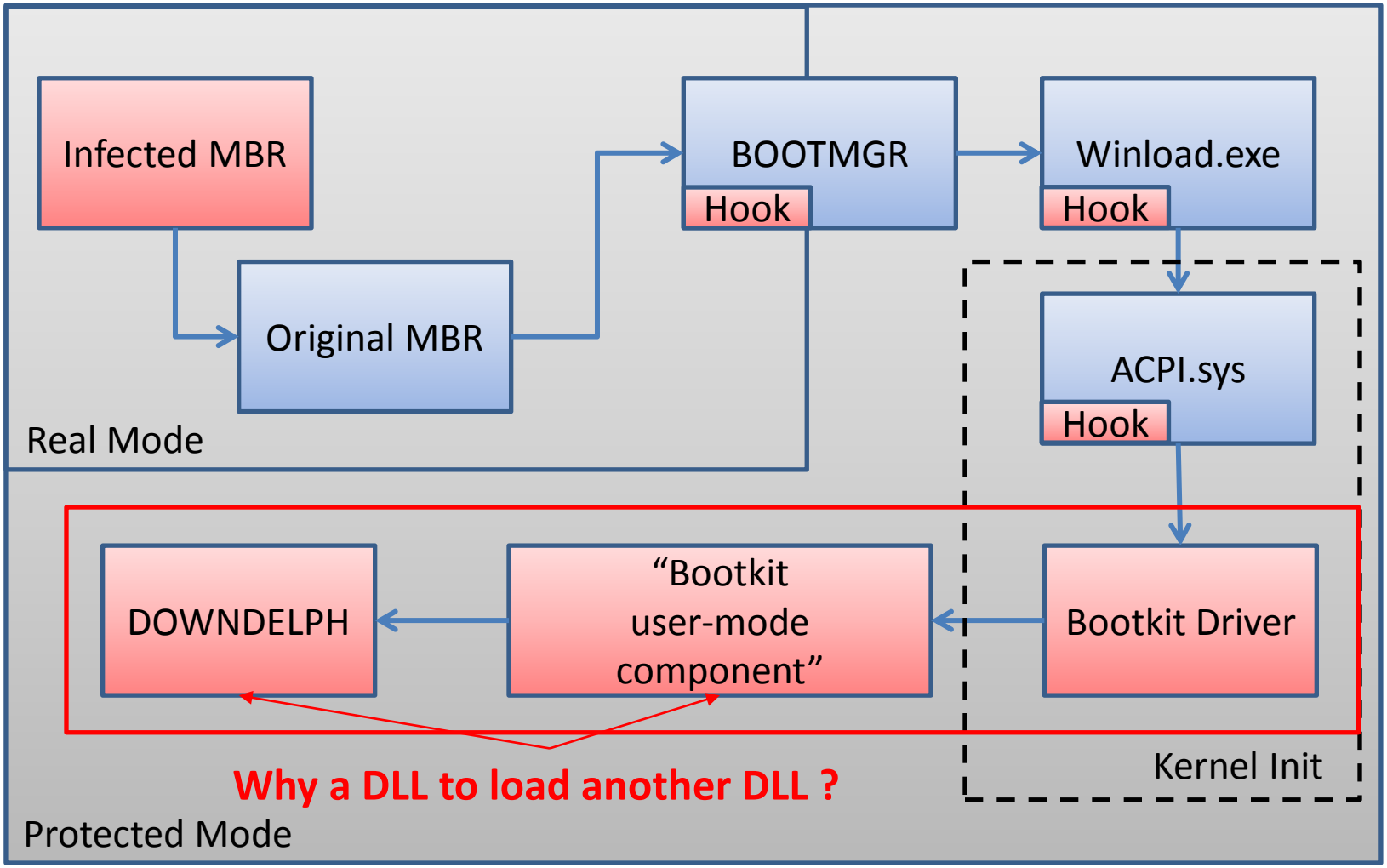

'User mode component of the bootkit has been injected.'

Who Are You Bootkit?

- Missing exported variable in DOWNDELPH

```
exportedVar = GetProcAddress(hModule, "m_bLoadedByBootkit");
if ( exportedVar )
  *(_DWORD *)exportedVar = TRUE;
```

Who Are You Bootkit?

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exportedVar = GetProcAddress(hModule, "m_bLoadedByBootkit");
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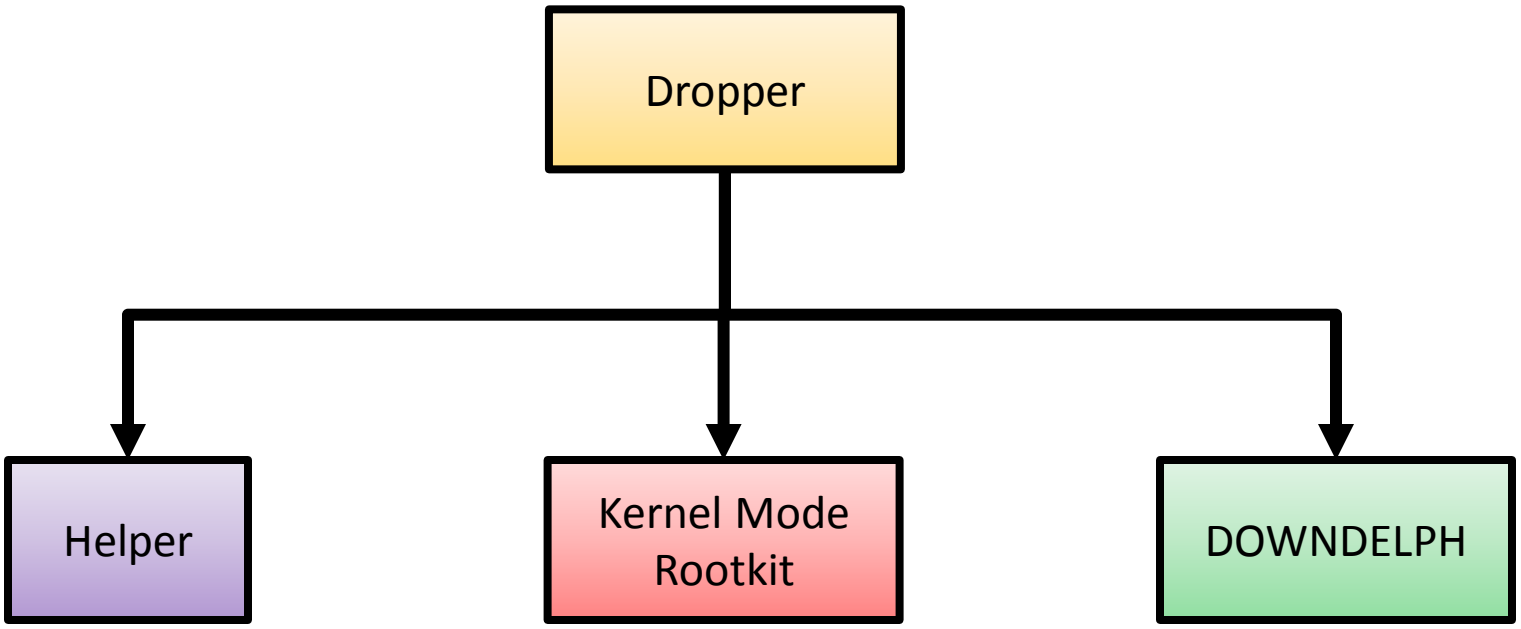
```

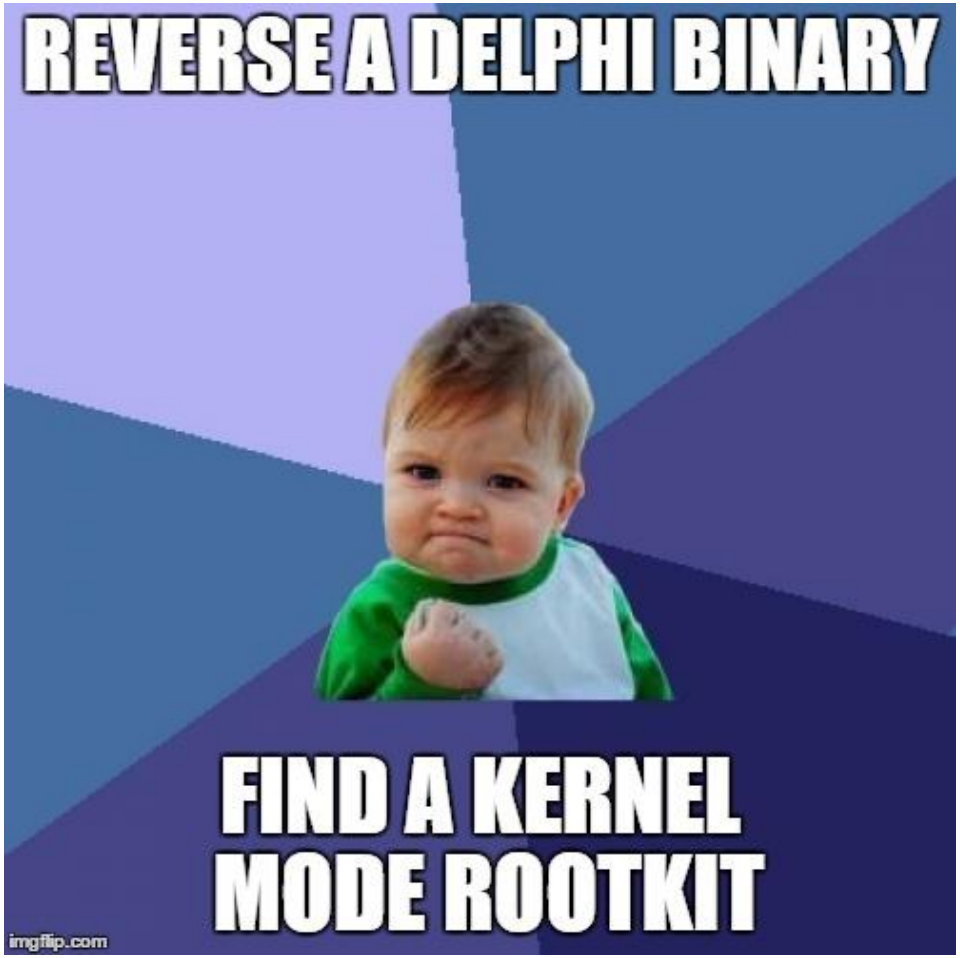
- Code sharing with BlackEnergy
  - Relocations fixing
  - DLL injection calling three exports (“Entry”, “ep_data” and “Dummy”)
  - …

But It's Not The End of The Story

2014 DOWNDELPH Samples



Not So Boring Component++



Kernel Mode Rootkit (1)

- Registered as a Windows service
- Injects DOWNDELPH into explorer.exe (APC)
- Hides files, folders and registry keys
- Relies on a set of rules:

HIDEDRV: >>>>>>>>Hide rules>>>>>>>> rules
HIDEDRV: **File rules**: \Device\[…]\dnscli1.dll
HIDEDRV: **File rules**: \Device\[…]\FsFlt.sys
HIDEDRV: **Registry rules**: \REGISTRY\[…]\FsFlt
HIDEDRV: **Registry rules**: \REGISTRY\[…]\FsFlt
HIDEDRV: **Registry rules**: \REGISTRY\[…]\FsFlt
HIDEDRV: **Inject dll**: C:\Windows\system32\mypathcom\dnscli1.dll
HIDEDRV: **Folder rules**: \Device\HarddiskVolume1\Windows\system32\mypathcom
HIDEDRV: <<<<<<<<XXXXX<<<<<<<< rules
HIDEDRV: <<<<<<<<Hide rules<<<<<<<< rules

Kernel Mode Rootkit (2)

How It Works

- Two implementations of the hiding ability:
  - SSDT hooking
  - Minifilter driver

Implementation Minifilter

```
v5 = FltGetFileNameInformation(callback_data, 1026u, &FileNameInformation);
if ( v5 >= 0 )
{
  // Is the accessed file or directory rootkit-protected?
  if ( FindRule(&FileNameInformation->Name, FILE_RULES) ||
       FindRule(&FileNameInformation->Name, DIRECTORY_RULES) )
  {
    if ( debug_level >= 5 )
    {
      DbgPrint("HIDEDRV: ");
      DbgPrint("PreHideCreate rule match %wZ\n", &FileNameInformation->Name);
    }
    // Hide file or directory presence
    callback_data->IoStatus.Status = STATUS_NOT_FOUND;
    FltSetCallbackDataDirty(callback_data);
    v6 = 4;
  }
  if ( FileNameInformation )
    FltReleaseFileNameInformation(FileNameInformation);
  result = v6;
```

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Who Are You Rootkit?

- Never documented (to the best of our knowledge)

- PDB paths:

```
d:\!work\etc\hi\Bin\Debug\win7\x86\fsflt.pdb
d:\!work\etc\hideinstaller_kis2013\Bin\Debug\win7\x64\fsflt.pdb
d:\new\hideinstaller\Bin\Debug\wxp\x86\fsflt.pdb
```

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```

To Summarize

- Seven different samples (!) of DOWNDELPH over the past three years
- One C&C server was up for two years
- Persistence methods:
  - Bootkit able to infect from Windows XP to Windows 7
  - Rootkit
- So, WHY such advanced persistence methods for such a simple component?
- DOWNDELPH downloaded SEDRECO + XAGENT in a few cases, so SEDNIT related for sure

SPECULATIVE MUMBLINGS

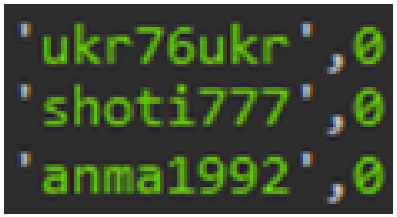
Call For Speculation

- The diversity of Sednit software is impressive (DOWNDELPH, bootkit, XAGENT, SEDKIT…)
- Diversity is good for their operations, as it makes detection and tracking harder
- How did they created this software ecosystem?

Sednit Development Process (1)

Developers Role

- Binaries are often compiled specifically for a target, *after* it has been infected



XAGENT SMTP logins/passwords

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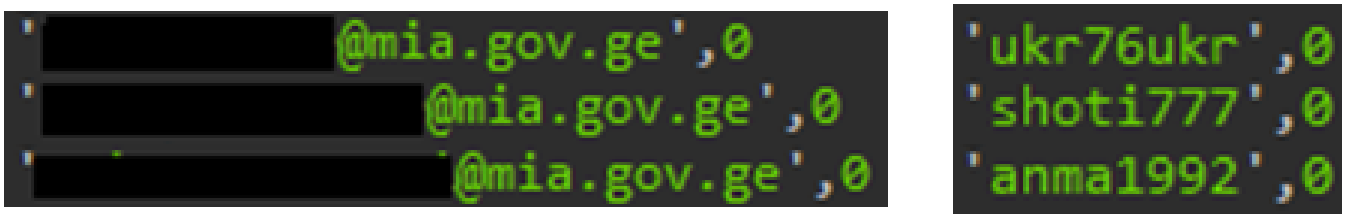

XAGENT SMTP logins/passwords

- Main software evolve regularly (XTUNNEL, SEDUPLOADER, XAGENT…)

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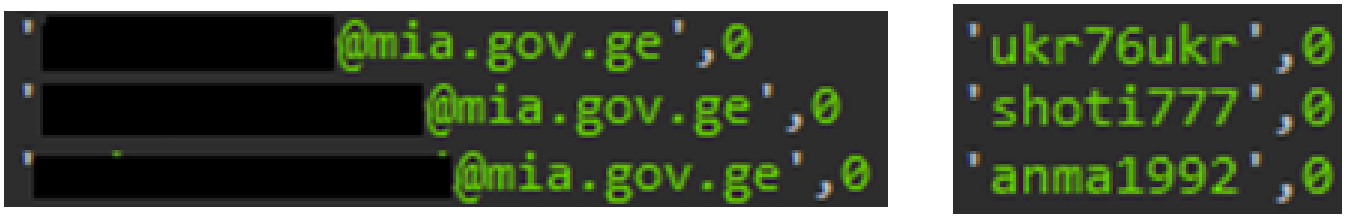

XAGENT SMTP logins/passwords

- Main software evolve regularly (XTUNNEL, SEDUPLOADER, XAGENT…)

Developers are part of the team,
not outsiders paid for a one-time job

Sednit Development Process (2)

Software Design

- Different Sednit software share some techniques:
  - RC4 keys built as concatenation of a hardcoded value and a randomly generated value

    (XAGENT, DOWNDELPH, SEDUPLOADER)
  - Hardcoded “tokens” in network messages

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  - Hardcoded “tokens” in network messages

    (XAGENT, SEDUPLOADER, SEDRECO)

The same developers may be behind this variety of software

Sednit Development Process (3)

Programming Errors

```
if(handleSendPacket != 0)
{
    pthread_exit(&handleGetPacket);
    //TerminateThread(handleSendPacket, 0);
    //CloseHandle(handleSendPacket);
}
```

Linux XAGENT

Communications termination

Sednit Development Process (3)

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Linux XAGENT

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msg_report = malloc(6u);
*(_DWORD *)msg_report = name.sin_addr.S_un.S_addr;// Target IP address
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XTUNNEL report message

Sednit Development Process (3)

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XTUNNEL report message

Developers do not have a code review process (“hackish” feeling)

Sednit Development Process (4)

Seeking Inspiration

- SEDUPLOADER employed novel persistence methods also found in crimeware, and shares code with Carberp
- DOWNDELPH bootkit code bears some similarities with BlackEnergy code

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Developers have ties with the crimeware underground

Sednit Development Process (5)

Having Fun

```
<body>
<center><p id="frodo">Plugin required to view this page.</p><div >
...
</body>
```

```
<v:group id="k" style="width:500pt;">
    <div id="lol">
        </div>
    </group>
```

ing-eroded-survey-warns/251166/messi.leonel

Sednit Development Process (5)

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ing-eroded-survey-warns/251166/messi.leonel

Developers are not working in a formal environment…

Mumblings Summary

Sednit has some in-house skilled developers, working with little supervision, and those guys have ties with crimeware underground

Conclusion

- Sednit activity increased a lot during the last two years (targeted attacks with a LOT of targets)
  - Heard about the DNC hack last week?

- Sednit toolkit in constant evolution, moar fun to come!

That’s All Folks!

- Feel free to poke us:

{calvet,campos,dupuy} .at. esetlabs.com

- Whitepaper coming soon!...

(“dans deux mois”)