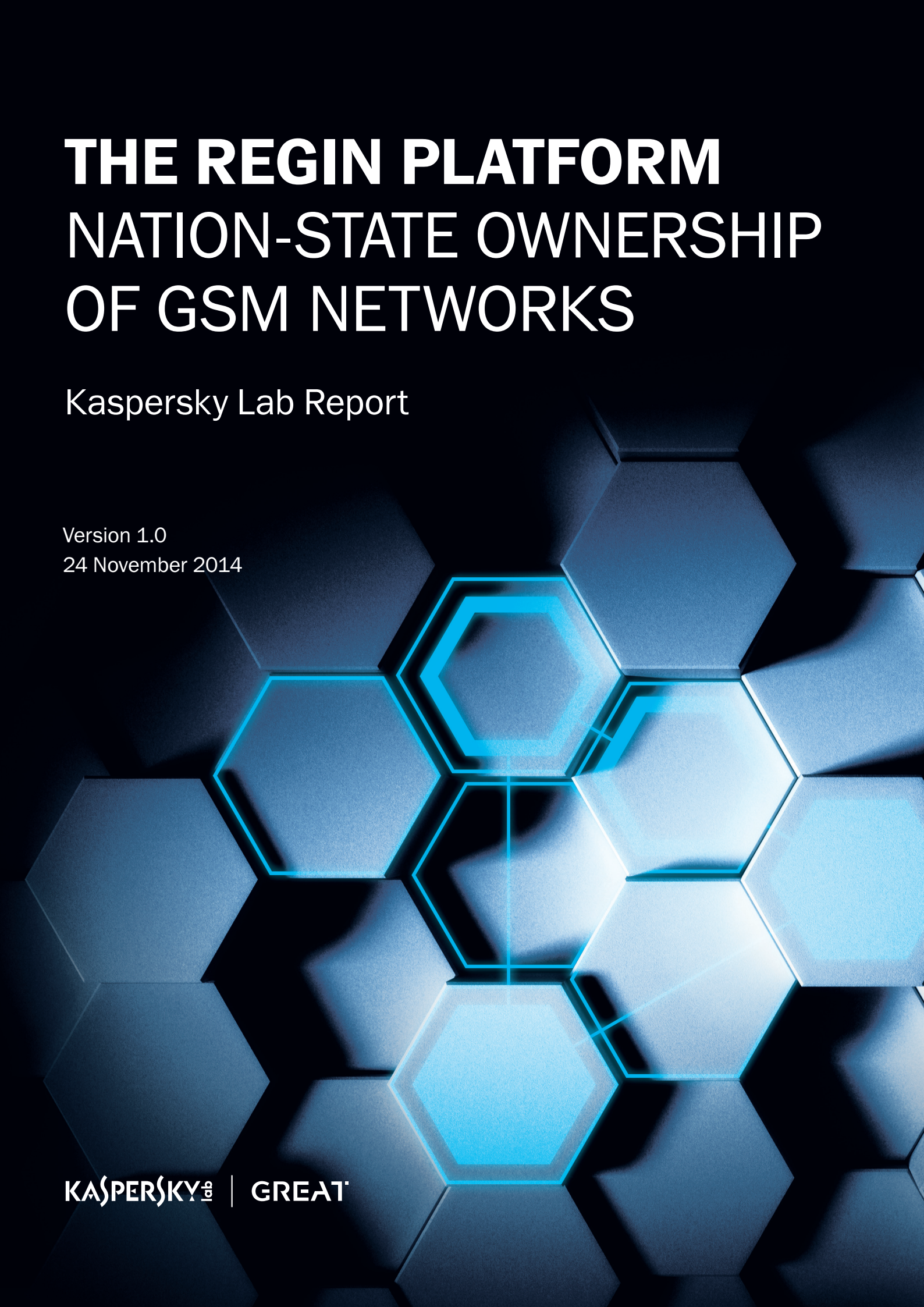
THE REGIN PLATFORM
NATION-STATE OWNERSHIP OF GSM NETWORKS

Kaspersky Lab Report

Version 1.0
24 November 2014



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Introduction, history

In the spring of 2012, following a Kaspersky Lab presentation on the unusual facts surrounding the Duqu malware (http://www.kaspersky.com/about/press/major_malware_outbreaks/duqu), a security researcher contacted us and mentioned that Duqu reminded him of another high-end malware incident. Although he couldn't share a sample, the researcher mentioned 'Regin', a type of malware attack that is now dreaded by security administrators in many government agencies around the world.

For the past three years we have been tracking this most elusive malware all around the world. From time to time samples would appear on various multi-scanner services, but they were all unrelated to each other, cryptic in functionality, and lacking in context.

It is unknown exactly when the first samples of Regin appeared in the wild. Some of them have timestamps dating back to 2003.

The victims of Regin fall into the following categories:

- Telecom operators
- Government institutions
- Multinational political bodies
- Financial institutions
- Research institutions
- Individuals involved in advanced mathematical/cryptographic research

So far, we've observed two main objectives of the attackers:

- Intelligence gathering
- Facilitating other types of attacks

While in most cases the attackers were focused on extracting sensitive information such as emails and other electronic documents, we have observed cases where the attackers compromised telecom operators to enable the launch of additional sophisticated attacks. This is discussed in detail in the **GSM attacks** section, below.

Perhaps one of the most well-known victims of Regin was Jean Jacques Quisquater (https://en.wikipedia.org/wiki/Jean-Jacques_Quisquater), a well-known Belgian cryptographer. In February 2014, Quisquater announced he was the victim of a sophisticated cyber-intrusion incident. We were able to obtain samples from the Quisquater case and confirm they belong to the Regin platform.

Another victim of Regin was a computer we call the '**Magnet of Threats**'. The computer belongs to a certain research institution and, besides Regin, it has been attacked by **Animal Farm**, **Itaduke**, **Mask/Careto**, **Turla**, and some other advanced threats that do not have public names, all co-existing happily on the same computer at some point.

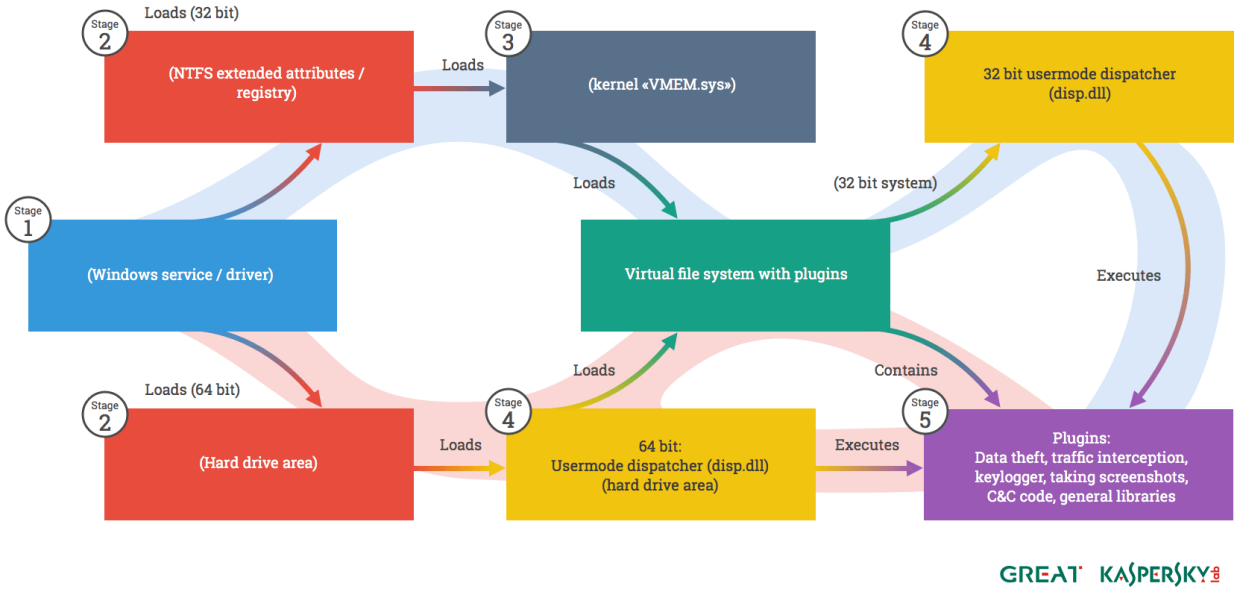
Initial compromise and lateral movement

The exact method used for the initial compromise remains a mystery, although several theories exist, including use of man-in-the-middle attacks with browser zero-day exploits. For some of the victims we observed tools and modules designed for lateral movement. So far we have not encountered any exploits. The replication modules are copied to remote computers using Windows administrative shares and then executed. Obviously this technique requires administrative privileges inside the victim's network. In several cases the infected machines were also Windows domain controllers. Targeting of system administrators via web-based exploits is a simple way of achieving immediate administrative access to the entire network.

The Regin platform

Although some private research groups refer to it as the 'Regin malware', it is not entirely accurate to use the term malware in this case. In essence, Regin is a cyberattack *platform*, which the attackers deploy in victim networks for total remote control at *all levels*.

The platform is extremely modular in nature and has multiple stages.



Regin platform diagram

Stage 1 – 32/64 bit

Known MD5s:
01c2f321b6bfdb9473c079b0797567ba
06665b96e293b23acc80451abb413e50
187044596bc1328efa0ed636d8aa4a5c
1c024e599ac055312a4ab75b3950040a
26297dc3cd0b688de3b846983c5385e5
2c8b9d2885543d7ade3cae98225e263b
47d0e8f9d7a6429920329207a32ecc2e
4b6b86c7fec1c574706cecedf44abded
6662c390b2bbbd291ec7987388fc75d7
744c07e886497f7b68f6f7fe57b7ab54
b269894f434657db2b15949641a67532
b29ca4f22ae7b7b25f79c1d4a421139d
b505d65721bb2453d5039a389113b566
ba7bb65634ce1e30c1e5415be3d1db1d
bfbe8c3ee78750c3a520480700e440f8
d240f06e98c8d3e647cbf4d442d79475
db405ad775ac887a337b02ea8b07fddc

ffb0b9b5b610191051a7bdf0806e1e47

In general, the first samples victims detect in their networks are stage 1 loaders. These are the easiest to notice because they are the only executables that exist directly on the victim's computer.

These samples use an odd technique to load the next stages, which until recently was unique to Regin. Interestingly, in mid-2012, the ZeroAccess gang implemented a very similar loading mechanism, which possibly suggests it learned about Regin and its unique features. (See http://www.symantec.com/connect/blogs/trojanzeroaccessc-hidden-ntfs-ea).

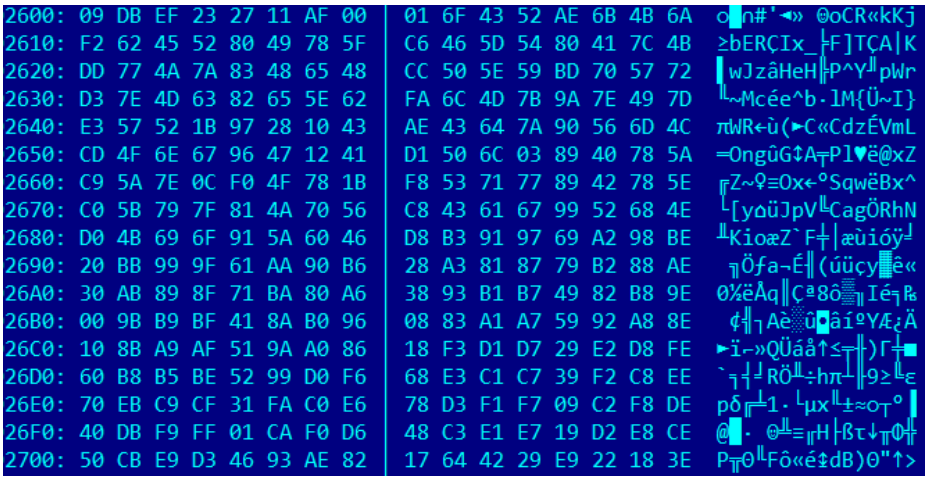
The particular feature used (or abused) by Regin to hide its next stages is called NTFS Extended Attributes (EA). Originally, these were implemented in Windows NT for compatibility with OS/2 applications; however, they made their way into later versions of Windows, namely 2000, XP and Vista. The malware hides its modules in NTFS EAs, splitting large files into several blocks of limited size. These are dynamically joined, decrypted and executed in memory.

Most of the stage 1 samples we have seen appear to have been built on top of other source code projects, which are 'piggybacked'; for instance, the Ser8UART project: http://www.mirrorservice.org/sites/downloads.sourceforge.net/s/se/ser8uart-driver/ser8uart-driver/Ser8UART%20%201.1.2.1/.

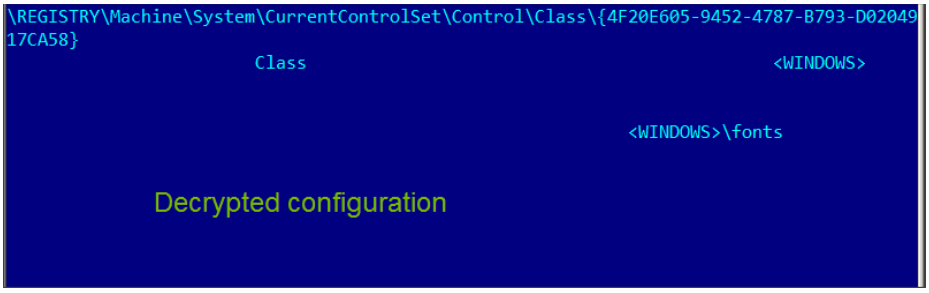
For instance, the Regin loader with md5 **01c2f321b6bfdb9473c079b0797567ba** was built on top of the Ser8UART source code. A careful examination however spots the encrypted configuration block at offset 0x5600.

We can assume the attackers take various low-level open-source projects or Windows DDK source codes and merge them together with their malicious loader. Hence, each stage 1 loader looks very different from others, as it contains random useless code from various other programs. This technique makes it more difficult to build reliable detection for the loaders.

Despite the differences, all stage 1 samples are similar in functionality. They contain an encrypted config block that points to the next stages:



Once decrypted, the block contains several folder names and registry key names:



In the example above, the stage 1 tries to load a second stage from the extended attributes of the system directory specified in the configuration block (in our case, the WINDOWS folder). It also tries to read additional data from the EAs of the second directory (in our case, the WINDOWS\fonts directory). The second attribute value is optional and may have been used to overcome size limitations.

If the first EA data block is missing, the module also tries to read the complete body of the 2nd stage from a registry value using the key and value names from the configuration block.

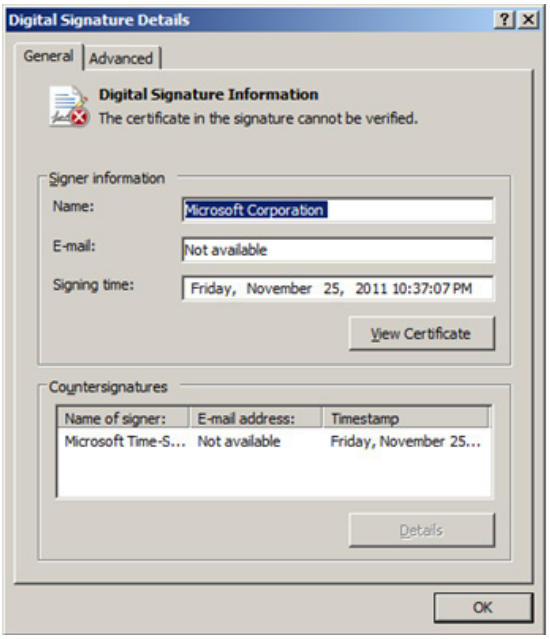
The body of the second stage is encrypted with one of two algorithms that are simple variations of XOR, and is supposed to be a PE file. The first stage loads that file in memory and calls its entry point function.

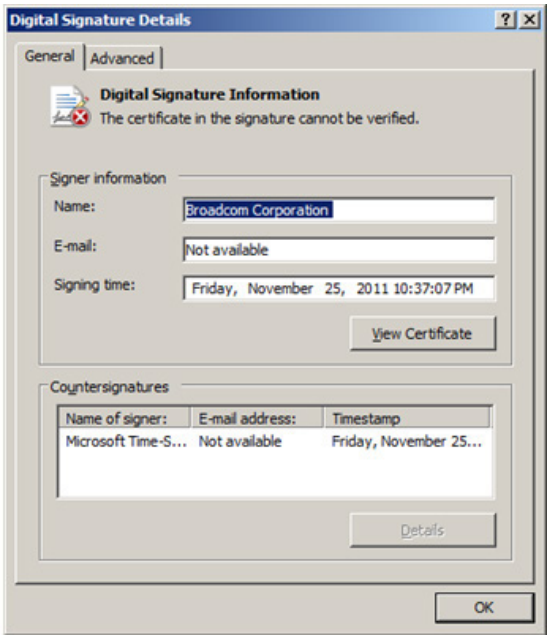
The 64-bit variant works in a slightly different way. Instead of storing the 2nd stage in the registry or extended attributes, the attackers preferred to store it after the end of the last partition on disk.

Known filenames for the 64-bit stage 1:

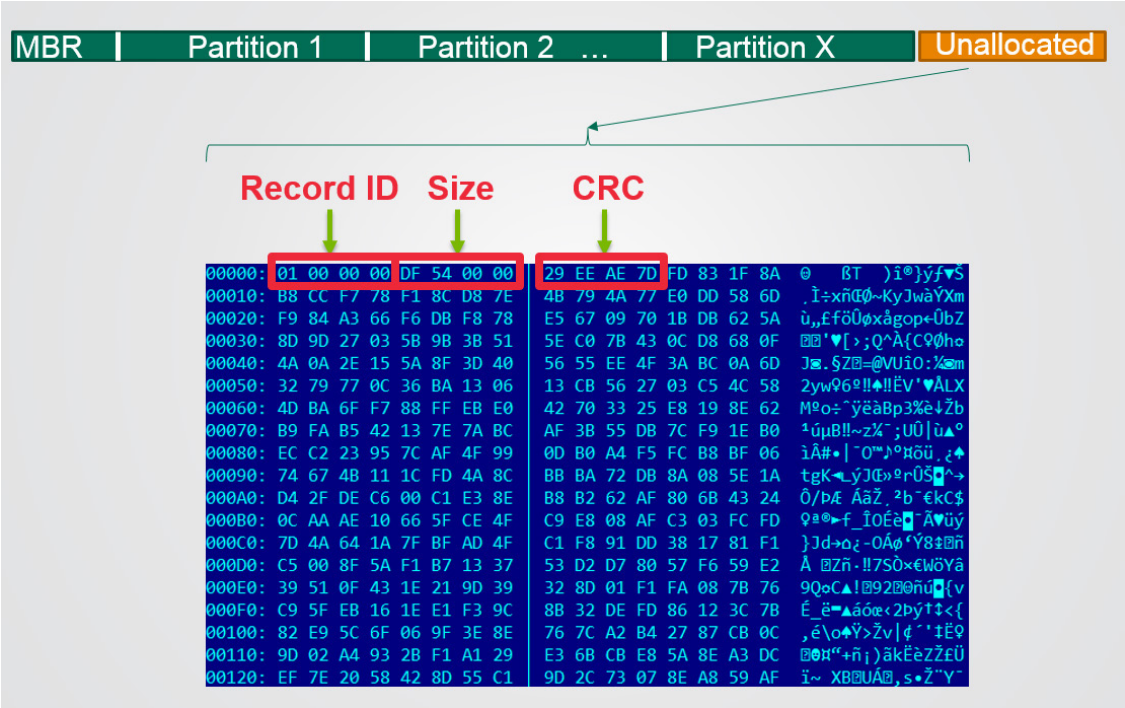
- system32\wsharp.dll – detected on a victim machine in Germany
- system32\wshnetc.dll – detected on a victim machine in Belgium

All the stage 1 modules for 64-bit systems were signed with fake digital certificates. The two fake certificates we identified are supposed to belong to Microsoft Corporation and Broadcom Corporation. During the infection phase, the attackers inject a trusted CA in the certificates chain, which instructs the system to trust their signatures.





Here is what the hard drive of a 64-bit system infected with Regin looks like:



Interestingly, while the 32-bit Regin stage 1 runs in kernel mode, on 64-bit systems the attacker code starts in user mode. This is perhaps due to the fact that it is more difficult to run kernel mode on modern Windows 64-bit systems.

Stage 2 – loader – 32-bit

Known MD5s:
18d4898d82fcb290dfed2a9f70d66833
b9e4f9d32ce59e7c4daf6b237c330e25

The second stage for 32-bit systems is implemented as a driver module. It has a configuration block encrypted in a similar way to the first stage module. The configuration block contains the names of two system directories that hold the encrypted third stage in their extended attributes. It also has the name of a registry value that may hold the body of the third stage in case the EAs are missing (for computers with a FAT/FAT32-formatted system disk).

Once the encrypted third stage is read from the registry or NTFS EAs, it is decrypted using the RC5 algorithm and a fixed 16-byte key that is hardcoded in the second stage. Then, it is decompressed using the NRV2e algorithm from the open-source UCL library. The second stage module loads the resulting binary in memory, validates that it is a valid PE file, and calls its entry point in a system thread.

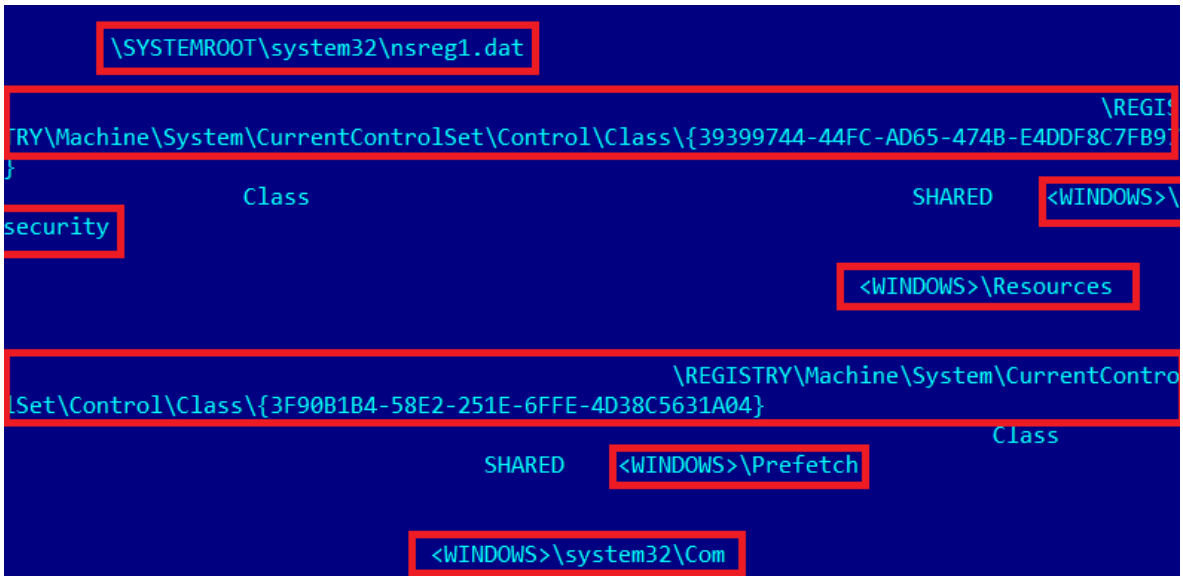
The second stage also creates a marker file that can be used to identify the infected machine. Known filenames for this marker are:

- **%SYSTEMROOT%\system32\nsreg1.dat**
- **%SYSTEMROOT%\system32\bssec3.dat**
- **%SYSTEMROOT%\system32\msrdc64.dat**

These files have their timestamp set to the timestamp of the system file '**%SYSTEMROOT%\system32\lsass.exe**'

The second stage has additional code for removing the startup code of Regin if signaled by the third stage. Its configuration data contains the locations of the first three stages, including registry keys, names of the directories that hold the encrypted EAs, and the location of the initial driver.

Essentially, the second stage can remove all the Regin stages from the system, effectively cleaning the machine and leaving only the encrypted VFS behind.



Decrypted configuration block of the second stage

Stage 2 – loader – 64-bit

Known MD5:
d446b1ed24dad48311f287f3c65aeb80

The 64-bit version of the second stage loader is a PE DLL module, since the 64-bit bootstrap chain operates in user mode.

Just like the first stage, it loads the encrypted body of the next stage from the end of the physical disk and decrypts it with a hardcoded RC5 key, then decompresses it using the nrv2 algorithm from the UCL library.

After decryption and decompression, the code checks if the next stage is a Windows PE DLL module, and if it is, it loads and executes it.

Stage 3 – 32-bit – kernel mode manager “VMEM.sys”

Known MD5s:
8486ec3112e322f9f468bdea3005d7b5
da03648948475b2d0e3e2345d7a9bbbb

On 32-bit systems, the third stage is implemented as a driver module and provides the basic functionality of the malicious framework. It is responsible for operating the encrypted virtual file system and loading additional plugins, and also provides several built-in plugins for the entire framework.

The module initializes the framework, sets up the plugin system and starts the actual work cycle of the malware. It also passes execution to the plugin id **50221** that is loaded from the VFS.

Built-in plugins provided by this module are:

Id	Plugin description
1	Core framework functionality
13	UCL library for compression and decompression using the nrv2 family of algorithms
15	RC5 encryption and decryption facilities
61	API for manipulating the encrypted virtual file system (VFS)
7	API for manipulating the encrypted virtual file system (VFS)
50225	API for code injection and kernel-mode hooking
50215	System information
50223	Module notification routines
50111	Utilities

Stage 3 – 64-bit

On 64-bit Windows systems, stage 3 is missing. Stage 2 loads the dispatcher directly from the disk and runs it.

Stage 4 (32-bit) / 3 (64-bit) – dispatcher module, 'disp.dll'

32-bit

Known MD5s:
1e4076caa08e41a5befc52efd74819ea
68297fde98e9c0c29cecc0ebf38bde95
6cf5dc32e1f6959e7354e85101ec219a
885dcd517faf9fac655b8da66315462d
a1d727340158ec0af81a845abd3963c1

64-bit

Known MD5:
de3547375fbf5f4cb4b14d53f413c503

The dispatcher library is the user-mode core of the framework. It is loaded directly as the third stage of the 64-bit bootstrap process, or extracted and loaded from the VFS as module 50221 as the fourth stage on 32-bit systems.

It implements a set of internal plugins:

Id	Plugin description
1	Core framework functionality
13	UCL library for compression and decompression using the nrv2 family of algorithms
15	RC5 encryption and decryption facilities

Id	Plugin description
61	API for manipulating the encrypted virtual file system (VFS)
7	API for manipulating the encrypted virtual file system (VFS)
11	File writer
51	Autostart installation routines
17	In-memory storage object
19	Configuration storage object
50035	Winsock-based network transport
25	Network transport using packet filters
9	Network transport-related utilities

The dispatcher takes care of the most complicated tasks of the Regin platform, such as providing an API to access virtual file systems, basic communications and storage functions, as well as network transport sub-routines. *In essence, the dispatcher is the brain that runs the entire platform.*

Stage 4 – Virtual File Systems (32/64-bit)

The most interesting code from the Regin platform is stored in encrypted file storages, known as Virtual File Systems (VFSes).

During our analysis we were able to obtain 24 VFSes from multiple victims around the world. Generally, these have random names and can be located in several places in the infected system:

Folder on disk	File name	Description
C:\Windows\System32\config\	SystemAudit.Evt, SystemLog.Evt, SecurityLog.Evt, Security-Audit.Evt, CACHE, SESSIONMGR	Old / ancient style, still around
C:\Windows\System32\	UsrClass.dat	Old / ancient style, still around
C:\WINDOWS\pchealth\helpctr\Database	cdata.dat, cdata.edb	Old / ancient style, still around
C:\Windows\System32\config\	UsrEvent.evt, ApplicationLog.Evt	Inside VFS, 6th stage
C:\Windows\Panther\	setup.etl.000	Used in a 64-bit infection
C:\Windows\System32\wbem\repository\	INDEX2.DATA, OBJECTS2.DATA	New style encryption, May 2014
C:\Windows\System32\	dnscache.dat, mregnx.dat displn32.dat, dmdskwk.dat, nvwrsnu.dat, tapiscfg.dat	New style encryption, May 2014

Each VFS has a structure that is very similar to a real disk file system such as FAT. The VFS files start with a header that provides basic information required to operate the file system. The header is followed by the bitmap of used/free sectors and then by the file table.

Offset	Size	Field description
00	02	Sector size
02	02	Maximum number of sectors
04	02	Maximum number of files
06	01	Unknown
07	04	CRC32 of first seven bytes of the header with seed 0x45
0B	04	Size of the file ID field, in bytes
0F	02	Number of files
11	maxSectors/8	Sector usage bitmap
		File table
		Sectors

Files are described by file table entries:

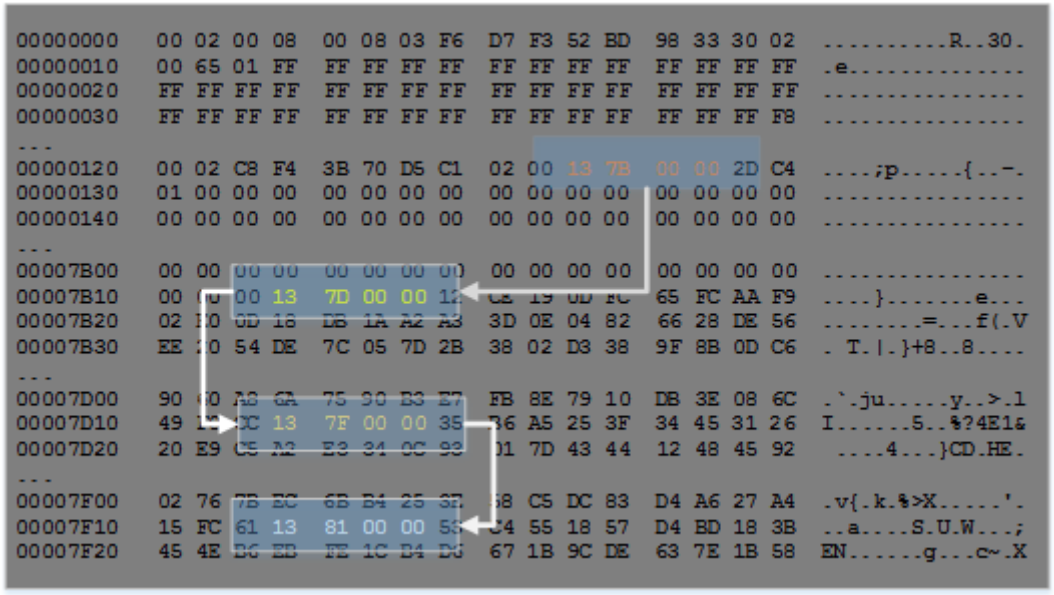
Offset	Size	Field description
00	04	CRC32 of file contents with seed 0x27
04	04	File size
08	04	Offset of the first sector
0C	Size of the file ID field	File ID / Plugin ID

Each sector starts with a 32-bit integer that is the offset of the next sector of the file.

00	Offset of the next sector
04	(Sector size)*byte of file data

An example:

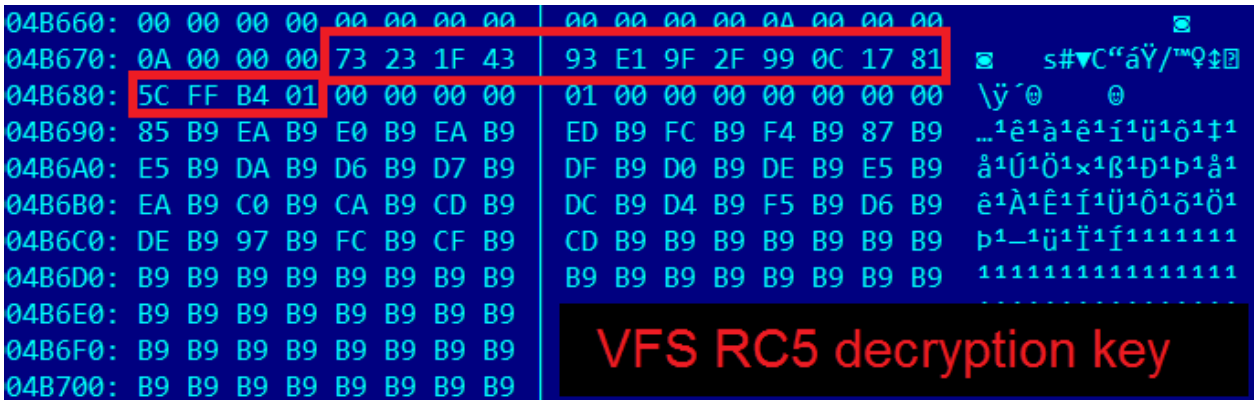
- File record at offset 0x122, file ID 50221, offset of the first sector 0x7B13
- Sector at 0x7B13, next sector at 0x7D13
- Sector at 0x7D13, next sector at 0x7F13,
- Sector at 0x7F13, next sector at 0x8113, etc.



Example of Regin VFS parsing

Although the structures of the file system are unencrypted, the file entries are encrypted. The encryption algorithm used is RC5, and many records are also compressed using the nrv2e algorithm from the UCL library. UCL is an open source implementation of the proprietary NRV ('Not Really Vanished') compression algorithm, and was originally used by the UPX tool. The reason why the attackers chose UCL is simple: it's small, compact and requires little to no additional memory for decompression.

Each VFS we encountered was encrypted with a 16 bytes key, which can vary from victim to victim. Based on our experience, most files were however encrypted with the same key, {**73 23 1F 43 93 E1 9F 2F 99 0C 17 81 5C FF B4 01**} stored in the dispatcher module or VMEM.sys kernel core.



VFS RC5 decryption key inside the dispatcher module (disp.dll)

In all, we observed about a dozen different VFS keys.

The following plugins were observed inside the VFSes we collected. These are all identified by a 16-bit number. The plugins are referenced by these numbers; they are like filenames on a normal file system and allow the dispatcher to easily load or reference them.

The binary modules are referenced by these numbers as plugin identifiers and usually have similar internal DLL names; e.g., the plugin with ID '50121' will have the internal name '50121.dll' in its export table. Compressed binary modules are accompanied by binary files with the same ID. These files contain the size of the decompressed module and are not included in the description.

Known data blocks and their configuration IDs:

0	4 bytes, unknown
1	Configuration data; timestamped binary data
4	4 bytes, unknown
9	Transport list and configurations, including peer hostnames and addresses
11	Location of an additional '.evt' file, usually 'ApplicationLog.evt'
13	Configuration data
14	Configuration data
15	Peer encryption keys
19	Peer network configuration data
25	Packet filter configuration
51	4 bytes, unknown
10001	Strings: 'legspinv2.6', 'WILLISCHECKv2.0', additional configuration data
10207	Configuration data
10404	Configuration data
10405	Configuration data
10505	1 byte; unknown
50009	Configuration data
50013	List of processes ('snort.exe', 'wireshark.exe', 'rundll32.exe', etc.)
50049	Log of GSM base station commands. Very rare, most interesting
50079	Location of a temporary file
50121	Drive names
50139	Event log provider names
50181	Data used by network transport plugins
50185	Plugin configuration
50227	Plugin configuration
50233	Process file name list (Explorer.exe, VMWareService.exe, Update.exe, Msiexec.exe, MailService.exe, etc.)
56001	Plugin configuration
57003	Configuration data

Known executable modules and their plugin IDs:

0	Data only
1	Core framework functionality
3	'3.sys' file timestamp manipulation; utilities

9	Network transport-related utilities
15	RC5 encryption and decryption facilities
25	Network transport using packet filters
27	ICMP network listener using raw sockets
10001	Command-line data collection and administration tools
10105	Utilities
10107	User logon and impersonation, user and domain name collection
10207	'pp.dll' Keylogger and clipboard sniffer
10211	Network share enumeration and manipulation
10309	Pipe/mailslot backend for plugin 10207
10405	Timestamp conversions
10507	Extraction from the protected storage and credential storages
11101	Detection of process hooks, directory enumeration
11701	Collects information about connected USB storage devices, creates storage files
20005	Driver installation/removal routines
20027	Collects information about sessions, installed browsers and proxy settings
20029	Remote registry manipulation routines
20073	Interception of system network drivers
50001	File system data collection and manipulation
50011	File data extraction
50013	Searches for potentially dangerous processes by module path/name (sniffers, debuggers, etc.)
50015	Retrieves current system time in Unix timestamp format
50017	Time-related utilities
50019	Sniffer using a packet filter
50025	System information, network share enumeration and scans
50029	Sniffer utilities
50033	Event log hooks
50035	Winsock-based network transport
50037	Network transport over HTTP
50047	Sniffer utilities
50049	HTTP/SMTP/SMB credentials sniffer
50051	Network transport over HTTPS
50053	Sniffer utilities

50061	Utilities
50063	BPF filter parser
50073	Network routing utilities
50079	Temporary file manipulation
50081	Network transport and configuration utilities
50097	DNS sniffer
50101	Extended system information; task scheduler data
50113	Utilities
50115	NDIS filter
50117	Network information: connections, adapters, DNS cache, statistics
50121	File system traversal
50123	HTTPS server, 'Microsoft-IIS/6.0'
50139	Windows event log reader
50185	Dumping users' password hashes (LM database)
50211	Driver hooking and hook detection
50215	'BEEP' driver, used by the 50211 plugin
50219	Injects plugins in processes
50221	'disp.dll' user-mode core of the framework
50223	Module notification routines
50225	API for code injection and kernel-mode hooking
50227	Code injection and hooking utilities
50231	Replication using network shares and local persistence, remote filename used: 'ADMIN$\SYSTEM32\SVCSTAT.EXE'
50233	Plugin injection utilities
50251	Keyboard driver hooking
50271	Network transport over SMB (named pipes)
55001	E-mail message extraction module '**U_STARBUCKS**'
55011	MS Exchange data extraction, appointment information
55007	POP3 proxy server, used in conjunction with plugin 55001
56001	Winsock networking routines

The attackers can dynamically add and delete plugins inside the VFS and each victim installation has a different set of plugins depending on the type of activity the attackers need to execute. For example, only some of the VFSes we have seen had lateral movement modules, designed for infecting other computers in the network.

Unusual modules and artifacts

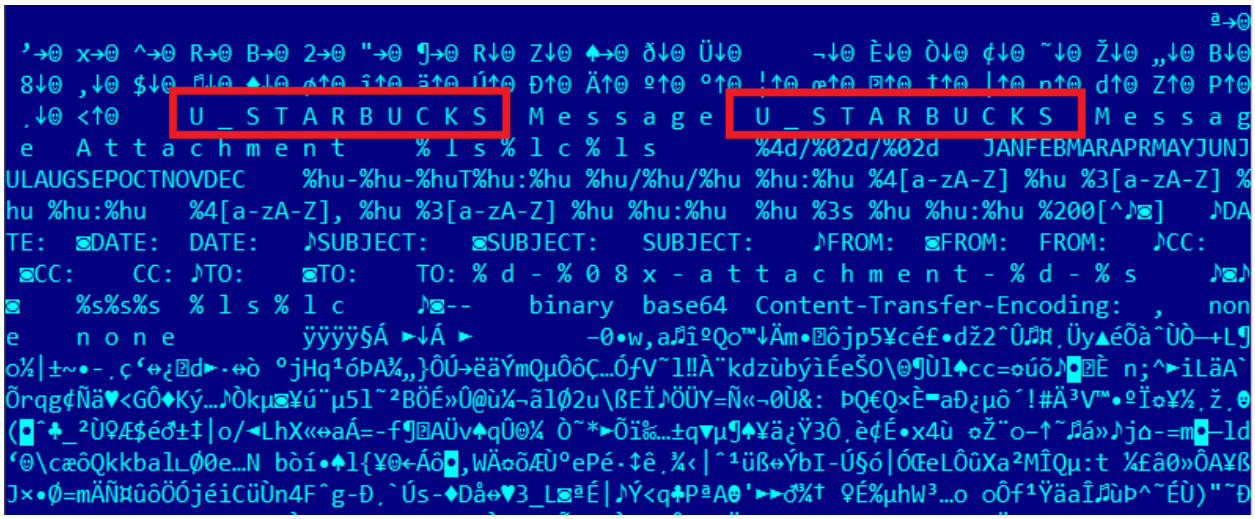
In this section we describe some of the most interesting findings about Regin.

Artifacts

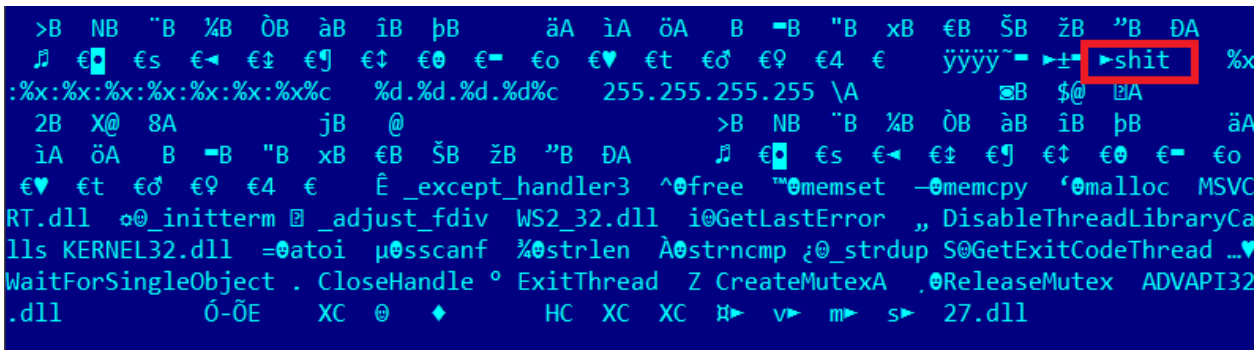
With high-end APT groups such as the one behind Regin, mistakes are very rare. Nevertheless, they do happen. Some of the VFSes we analyzed contain words that appear to be the respective codenames of the modules deployed on the victim:

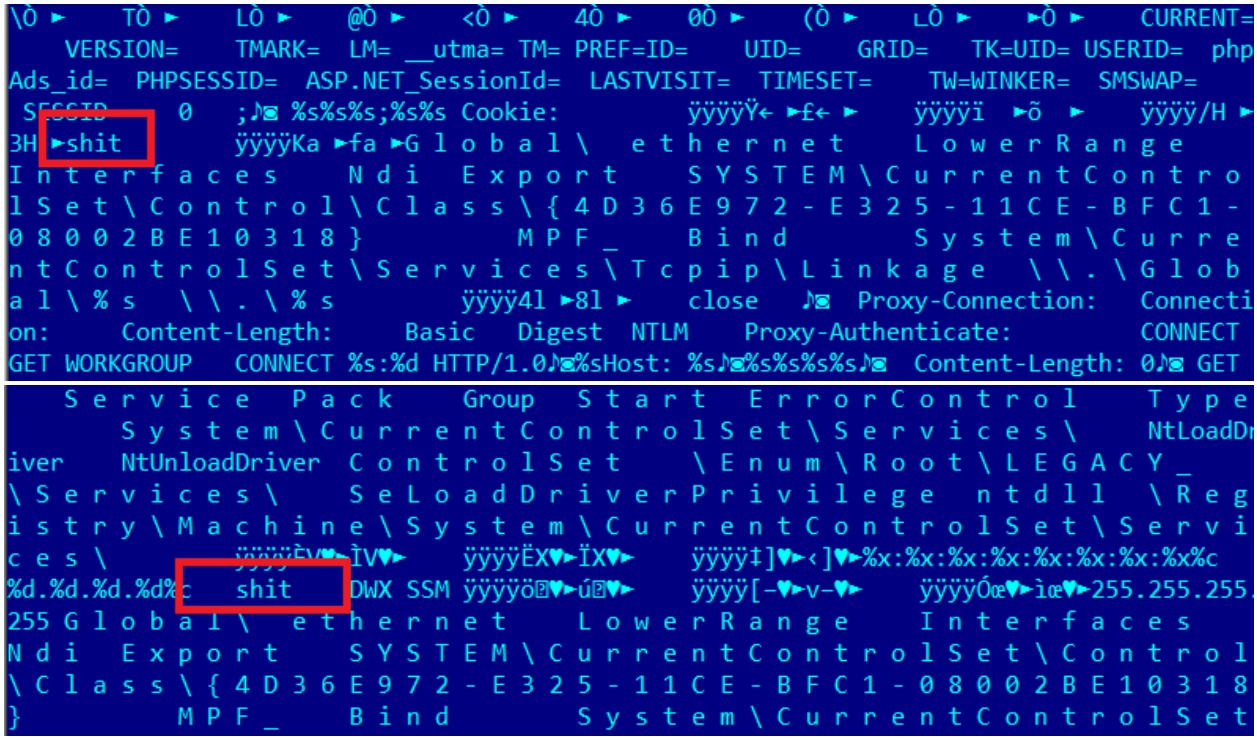
- **legspinv2.6 and LEGSPINv2.6**
- **WILLISCHECKv2.0**
- **HOPSCOTCH**

Another module we found, which is a plugin type 55001.0, references U_STARBUCKS:



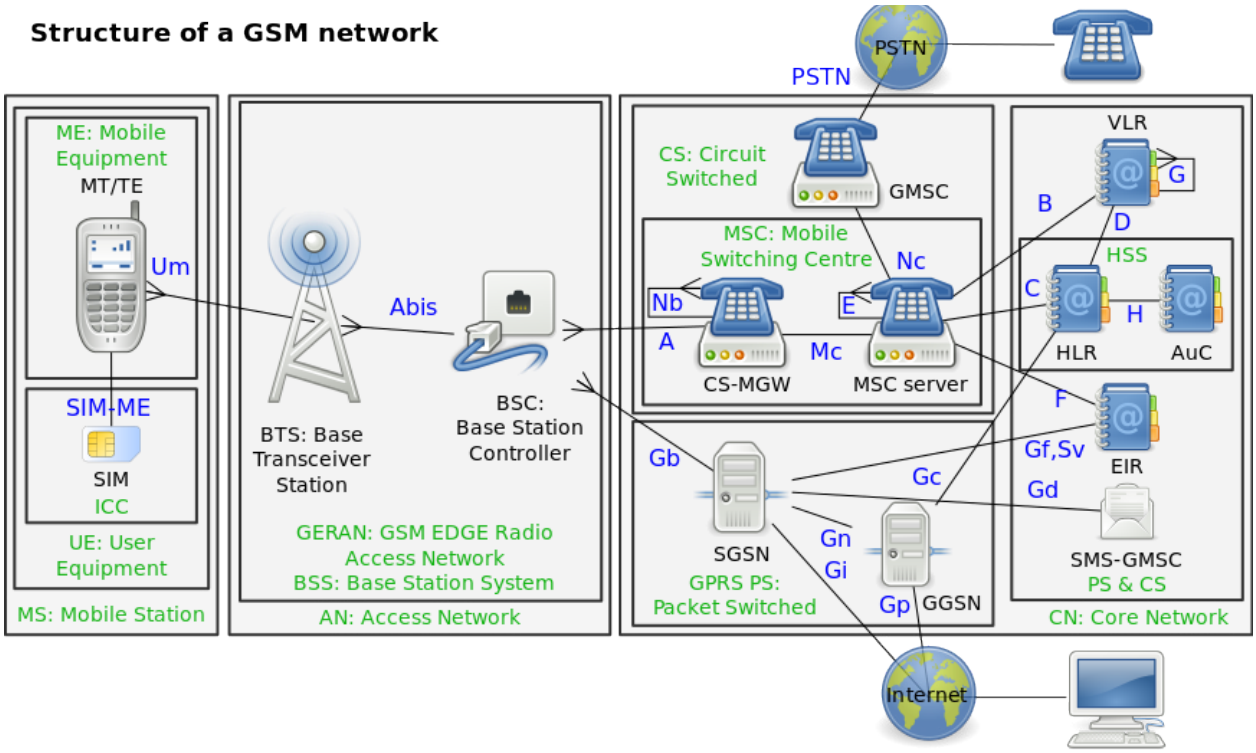
Finally, the word 'shit' appears in many places throughout the code and modules.




shit
shit

GSM targeting

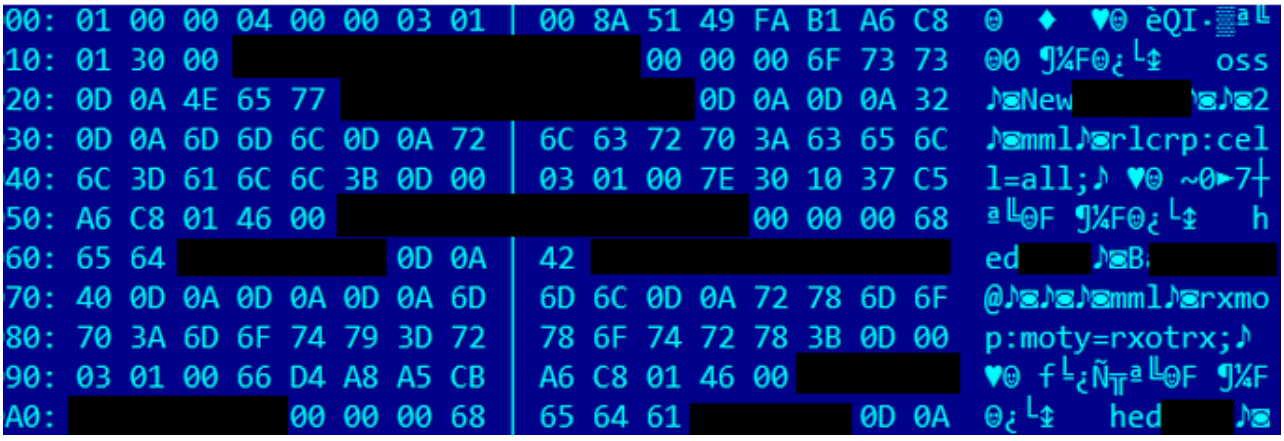
The most interesting aspect we have found so far regarding Regin relates to an infection of a large GSM operator. One VFS encrypted entry we located had internal id 50049.2, and appears to be an activity log on a GSM Base Station Controller.



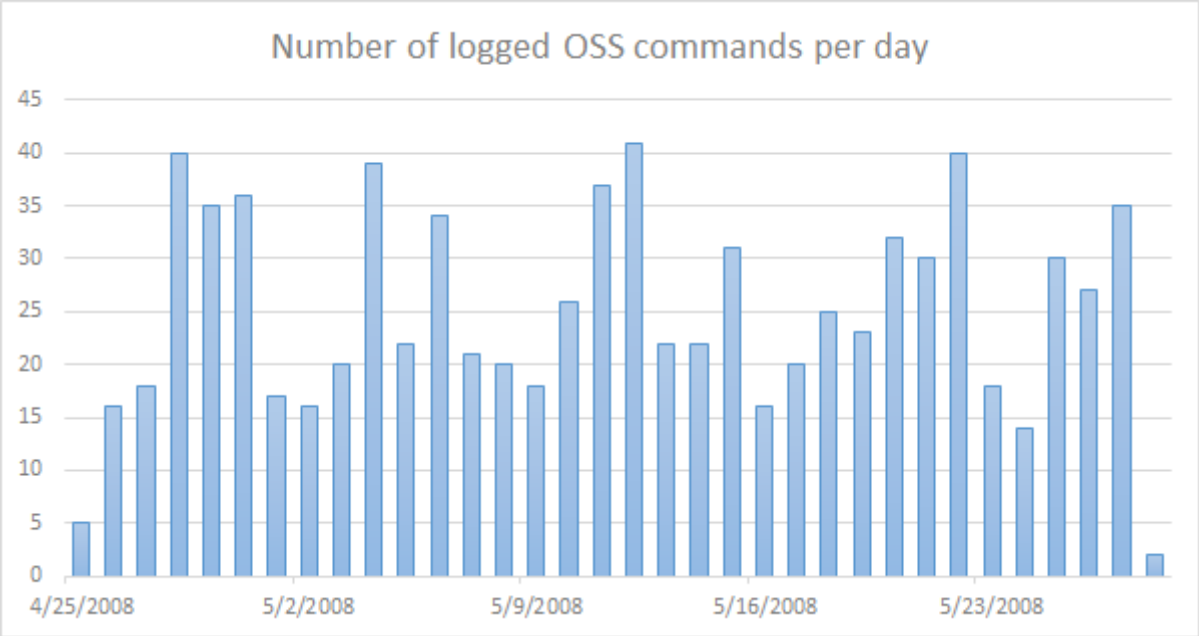
From https://en.wikipedia.org/wiki/Base_station_subsystem

According to the GSM documentation (http://www.telecomabc.com/b/bsc.html): '*The Base Station Controller (BSC) is in control of and supervises a number of Base Transceiver Stations (BTS). The BSC is responsible for the allocation of radio resources to a mobile call and for the handovers that are made between base stations under his control. Other handovers are under the control of the MSC.*'

Here's a look at the decoded Regin GSM activity log:



This log is about 70KB in size and contains hundreds of entries like the ones above. It also includes timestamps that indicate exactly when the command was executed.



The entries in the log appear to contain Ericsson OSS MML (Man-Machine Language as defined by ITU-T) commands (see https://en.wikipedia.org/wiki/Operations_support_system).

Here's a list of some commands issued on the Base Station Controller, together with some of their timestamps:

```
2008-04-25 11:12:14: rxmop:moty=rxotrx;
2008-04-25 11:58:16: rxmsp:moty=rxotrx;
2008-04-25 14:37:05: rlcrp:cell=all;
2008-04-26 04:48:54: rxble:mo=rxocf-170,subord;
2008-04-26 06:16:22: rxtcp:MOty=RXOtg,cell=kst022a;
2008-04-26 10:06:03: IOSTP;
2008-04-27 03:31:57: rlstc:cell=pty013c,state=active;
2008-04-27 06:07:43: allip:acl=a2;
2008-04-28 06:27:55: dtstp:DIP=264rbl2;
2008-05-02 01:46:02: rlstp:cell=all,state=halted;
2008-05-08 06:12:48: rlmfc:cell=NGR035W,mbcchno=83&512&93&90&514&522,listtype=active;
2008-05-08 07:33:12: rlnri:cell=NGR058y,cellr=ngr058x;
2008-05-12 17:28:29: rrtpp:trapool=all.
```

Descriptions for the commands:

rxmop - check software version type;

rxmsp - list current call forwarding settings of the Mobile Station;

rlcrp - list off call forwarding settings for the Base Station Controller;

rxble - enable (unblock) call forwarding;

rxtcp - show the Transceiver Group of particular cell;

allip - show external alarm;

dtstp - show Digital Path (DIP) settings (DIP is the name of the function used for supervision of the connected PCM (Pulse Code Modulation) lines);

rlstc - activate cell(s) in the GSM network;

rlstp - stop cell(s) in the GSM network;

rlmfc - add frequencies to the active broadcast control channel allocation list;

rlnri - add cell neighbor;

rrtpp - show radio transmission transcoder pool details.

The log seems to contain not only the executed commands but also usernames and passwords of some engineering accounts:

```
sed[snip]:Alla[snip]
hed[snip]:Bag[snip]
oss:New[snip]
administrator:Adm[snip]
```

In total, the log indicates that commands were executed on 136 different cells. Some of the cell names include '**prn021a, gzn010a, wdk004, kbl027a, etc…**'. The command log we obtained covers a period of about one month, from April 25, 2008 through May 27, 2008. It is unknown why the commands stopped in May 2008 though; perhaps the infection was removed or the attackers achieved their objective and moved on. Another explanation is that the attackers improved or changed the malware to stop saving logs locally and that is why only some older logs were discovered.

Communication and C&C

The C&C mechanism implemented in Regin is extremely sophisticated and relies on communication drones deployed by the attackers throughout the victim networks. Most victims communicate with another machine in their own internal network through various protocols as specified in the config file. These include HTTP and Windows network pipes. The purpose of such a complex infrastructure is to achieve two goals: (i) to give attackers access deep into the network, potentially bypassing air gaps; and (ii) to restrict as much as possible the traffic to the C&C.

Here's a look at the decoded configurations::

```
17.3.40.101 transport 50037 0 0 y.y.y.5:80 ; transport 50051 217.y.y.yt:443
17.3.40.93 transport 50035 217.x.x.x:443 ; transport 50035 217.x.x.x:443
50.103.14.80 transport 27 203.199.89.80 ; transport 50035 194.z.z.z:8080
51.9.1.3 transport 50035 192.168.3.3:445 ; transport 50035 192.168.3.3:9322
18.159.0.1 transport 50271 DC ; transport 50271 DC
```

In the above table we see configurations extracted from several victims that bridge together infected machines in what appears to be virtual networks: 17.3.40.x, 50.103.14.x, 51.9.1.x, 18.159.0.x. One of these routes reaches out to the 'external' C&C server at **203.199.89.80**.

The numbers right after the 'transport' indicate the plugin that handles the communication. These are in our case:

- 27 - ICMP network listener using raw sockets
- 50035 - Winsock-based network transport
- 50037 - Network transport over HTTP
- 50051 - Network transport over HTTPS
- 50271 - Network transport over SMB (named pipes)

The machines located on the border of the network act as routers, effectively connecting victims from inside the network with C&Cs on the Internet.

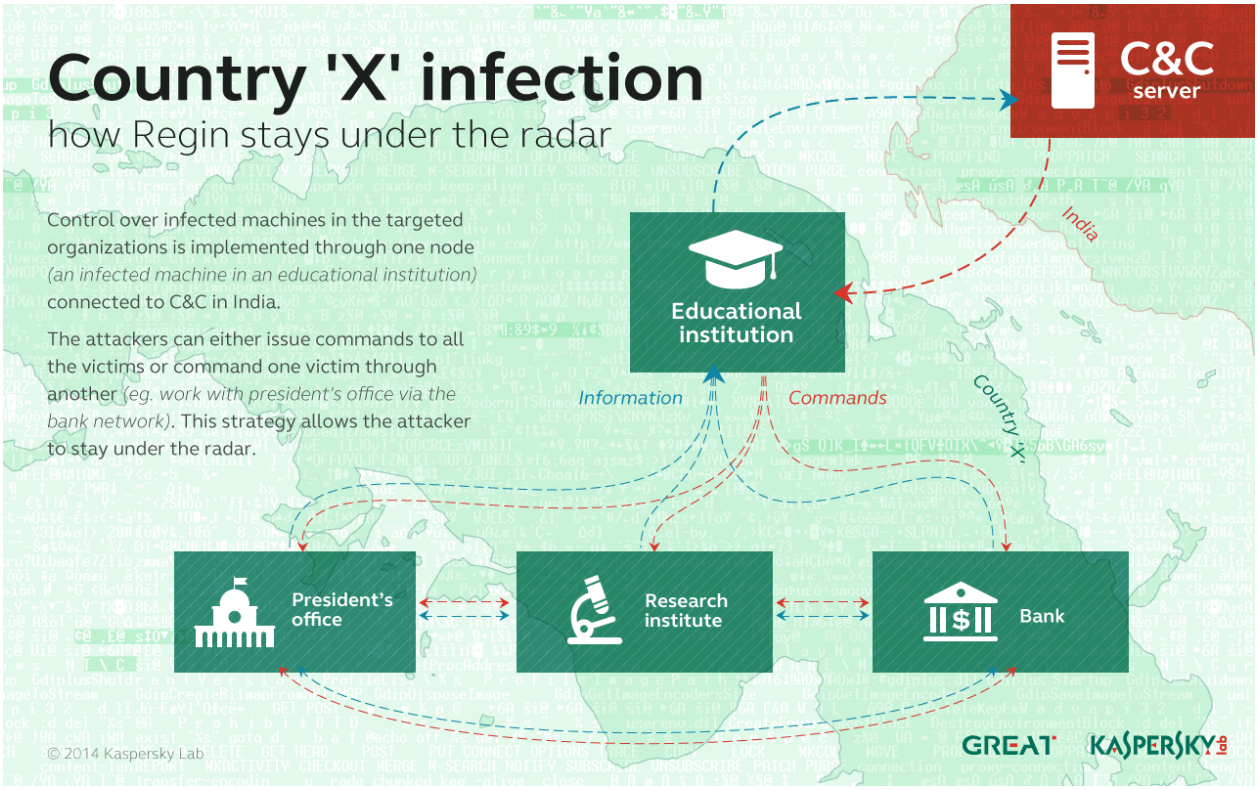
After decoding all the configurations we have collected, we were able to identify the following external C&Cs.

C&C server IP	Location	Description
61.67.114.73	Taichung, Taiwan	Chwbn
202.71.144.113	Chetput, India	Chennai Network Operations (team-m.co)
203.199.89.80	Thane, India	Internet Service Provider
194.183.237.145	Brussels, Belgium	Perceval S.a.

One particular case includes a country in the Middle East. It was rather astonishing, so we thought it should be mentioned. In this country all the victims we identified communicate with each other, forming a peer-to-peer network. The P2P network includes **the president's office**, **a research center**, **an educational institution network** and **a bank**.

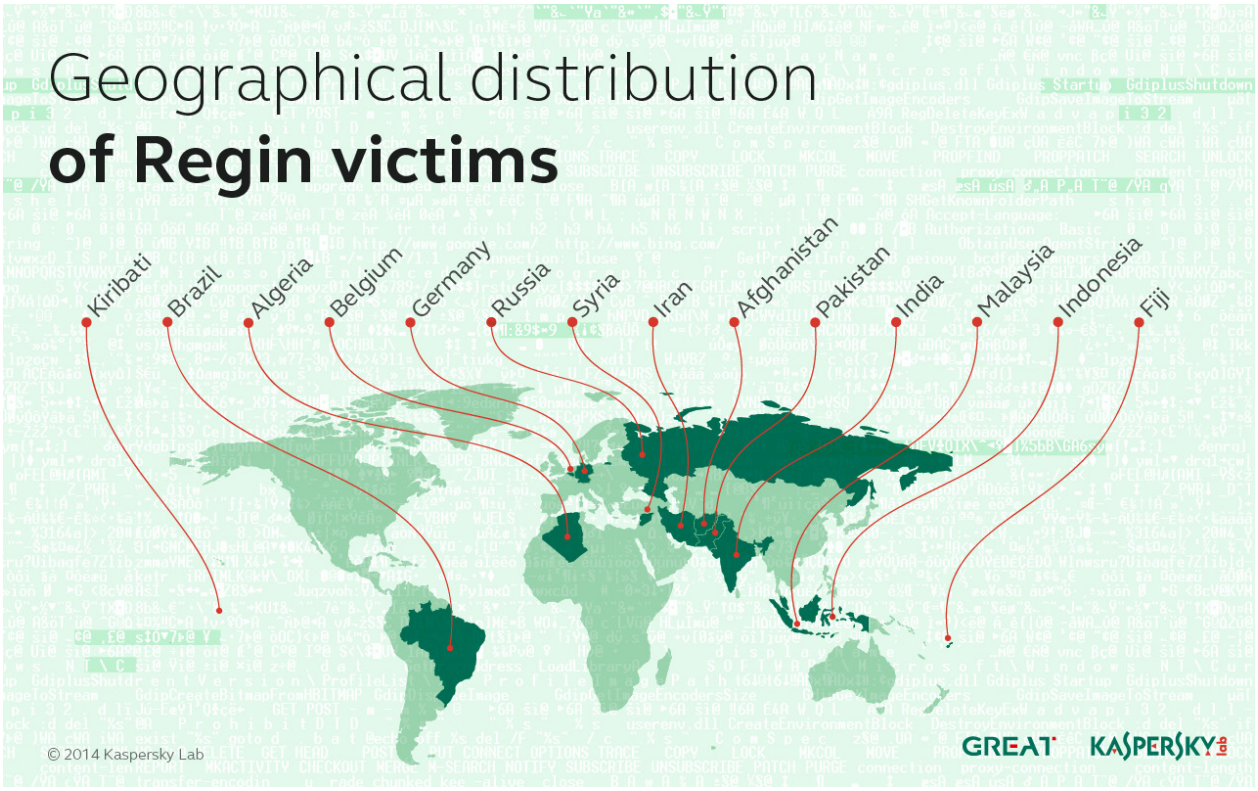
Spread across the country, these victims are all interconnected with each other. One of the victims contains a translation drone, which has the ability to forward packets outside the country, to the C&C in India.

This represents a rather interesting command-and-control mechanism, which is guaranteed to raise little suspicion. For instance, if all commands to the president's office are sent through the bank's network, then all the malicious traffic visible to the president's office sysadmins will only be with the bank, in the same country.



Victim statistics

Over the past two years we have been collecting statistics on the attacks and victims of Regin. These were aided by the fact that even after the malware is uninstalled, certain artifacts are left behind, which can help identify an infected (but cleaned) system. For instance, we have seen several cases where the systems were cleaned but the '**msrdc64.dat**' infection marker was left behind.



So far, victims of Regin have been identified in **14 countries**:

- **Afghanistan**
- **Algeria**
- **Belgium**
- **Brazil**
- **Fiji**
- **Germany**
- **India**
- **Indonesia**
- **Iran**
- **Kiribati**
- **Malaysia**
- **Pakistan**
- **Russia**
- **Syria**

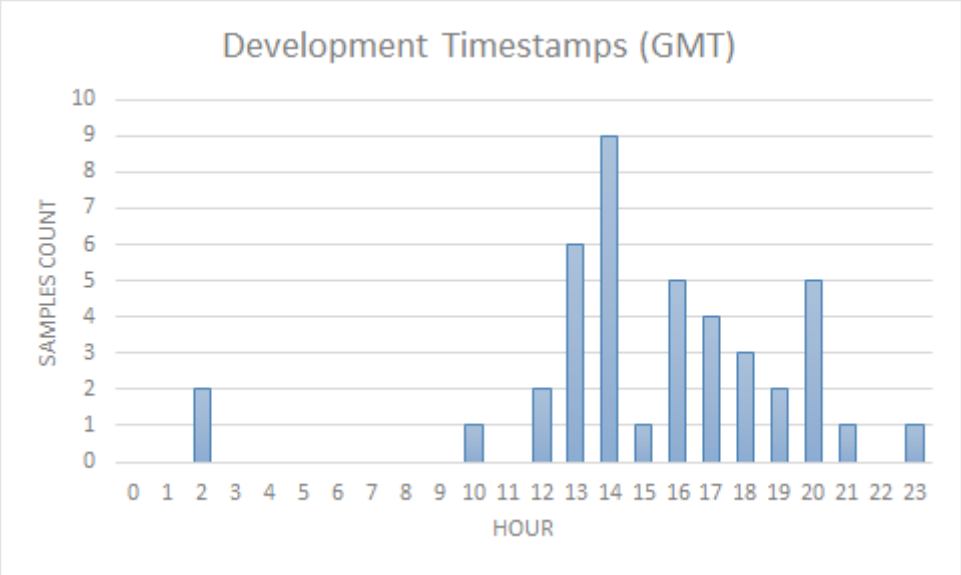
In total, we counted **27 different victims**, although it should be pointed out that the definition of a victim here refers to a full entity, including its entire network. The number of unique PCs infected with Regin is of course much, much higher.

From the map above, **Fiji** and **Kiribati** are unusual, because we rarely see such advanced malware in such remote, tiny countries. In particular, the victim in Kiribati is most unusual. To put this into context, Kiribati is a small island in the Pacific with a population around 100,000. According to experts, Kiribati is probably going to become one of the first victims of global warming, as it will be under water by 2050. (http://www.businessinsider.com/pacific-island-nation-kiribati-sinking-2014-5?op=1)

Attribution

Considering the complexity and cost of Regin's development, it is likely that this operation is supported by a nation state. While attribution remains a very difficult problem when it comes to professional attackers such as the ones behind Regin, certain metadata extracted from the samples is still worth a look.

We have collected timestamps from samples, which are normally put automatically by the development software:



As this information could be easily altered by the developers, it is up to the reader to attempt to interpret this: as an intentional false flag, or a non-critical indicator left by the developers.

More information about Regin is available to Kaspersky Intelligent Services' clients. Contact: intelreports@kaspersky.com

Conclusions

For more than a decade, a sophisticated group known as Regin has targeted high-profile entities around the world with an advanced malware platform. As far as we can tell, the operation is still active, although the malware may have been upgraded to more sophisticated versions. The most recent sample we have seen was from a 64-bit infection. This infection was still active in the spring of 2014.

The name Regin is apparently a switched around 'In Reg', short for 'In Registry', as the malware can store its modules in the registry. This name and the detections first appeared in anti-malware products around March 2011.

In some ways the platform reminds us of another sophisticated malware: Turla (http://securelist.com/analysis/publications/65545/the-epic-turla-operation/). Some similarities include the use of virtual file systems and the deployment of communication drones to bridge networks together. Yet through their implementation, coding methods, plugins, hiding techniques and flexibility, *Regin surpasses Turla as one of the most sophisticated attack platforms* we have ever analyzed.

The ability of this group to penetrate and monitor GSM networks is perhaps the most unusual and interesting aspect of these operations. In today's world, we have become too dependent on cellphone networks that rely on ancient communication protocols with little or no security available for the end user. Although all GSM networks have mechanisms embedded that allow entities such as law enforcement to track suspects, there are other parties which can gain this ability and then abuse it to launch other types of attacks against mobile users.

Kaspersky Lab products detect modules from the Regin platform as: Trojan.Win32.Regin.gen and Rootkit.Win32.Regin.

If you detect a Regin infection in your network, contact us at: intelservices@kaspersky.com

Technical appendix and indicators of compromise:

Yara rules:

```
rule apt_regin_vfs {
meta:
    copyright = "Kaspersky Lab"
    description = "Rule to detect Regin VFSes"
    version = "1.0"
    last_modified = "2014-11-24"
strings:
    $a1={00 02 00 08 00 08 03 F6 D7 F3 52}
    $a2={00 10 F0 FF F0 FF 11 C7 7F E8 52}
    $a3={00 04 00 10 00 10 03 C2 D3 1C 93}
    $a4={00 04 00 10 C8 00 04 C8 93 06 D8}
condition:
    ($a1 at 0) or ($a2 at 0) or ($a3 at 0) or ($a4 at 0)
}
rule apt_regin_dispatcher_disp_dll {
meta:
    copyright = "Kaspersky Lab"
    description = "Rule to detect Regin disp.dll dispatcher"
    version = "1.0"
    last_modified = "2014-11-24"
strings:
    $mz="MZ"
    $string1="shit"
    $string2="disp.dll"
    $string3="255.255.255.255"
    $string4="StackWalk64"
    $string5="imagehlp.dll"
condition:
    ($mz at 0) and (all of ($string*))
}
rule apt_regin_2013_64bit_stage1 {
meta:
    copyright = "Kaspersky Lab"
    description = "Rule to detect Regin 64 bit stage 1 loaders"
    version = "1.0"
    last_modified = "2014-11-24"
    filename="wshnetc.dll"
    md5="bddf5afbea2d0eed77f2ad4e9a4f044d"
    filename="wsharp.dll"
    md5="c053a0a3f1edcbbfc9b51bc640e808ce"
strings:
    $mz="MZ"
       $a1="PRIVHEAD"
       $a2="\\\\.\\PhysicalDrive%d"
       $a3="ZwDeviceIoControlFile"
condition:
    ($mz at 0) and (all of ($a*)) and filesize < 100000
}
```

```
rule apt_regin_2011_32bit_stage1 {
meta:
    copyright = "Kaspersky Lab"
    description = "Rule to detect Regin 32 bit stage 1 loaders"
    version = "1.0"
    last_modified = "2014-11-24"
strings:
    $key1={331015EA261D38A7}
    $key2={9145A98BA37617DE}
    $key3={EF745F23AA67243D}
    $mz="MZ"
condition:
    ($mz at 0) and any of ($key*) and filesize < 300000
}
rule apt_regin_rc5key {
meta:
    copyright = "Kaspersky Lab"
    description = "Rule to detect Regin RC5 decryption keys"
    version = "1.0"
    last_modified = "2014-11-24"
strings:
    $key1={73 23 1F 43 93 E1 9F 2F 99 0C 17 81 5C FF B4 01}
    $key2={10 19 53 2A 11 ED A3 74 3F C3 72 3F 9D 94 3D 78}
condition:
any of ($key*)
}
```

MD5s:

Stage 1 files, 32 bit:

06665b96e293b23acc80451abb413e50
187044596bc1328efa0ed636d8aa4a5c
1c024e599ac055312a4ab75b3950040a
2c8b9d2885543d7ade3cae98225e263b
4b6b86c7fec1c574706cecedf44abded
6662c390b2bbbd291ec7987388fc75d7
b269894f434657db2b15949641a67532
b29ca4f22ae7b7b25f79c1d4a421139d
b505d65721bb2453d5039a389113b566
26297dc3cd0b688de3b846983c5385e5
ba7bb65634ce1e30c1e5415be3d1db1d
bfbe8c3ee78750c3a520480700e440f8
d240f06e98c8d3e647cbf4d442d79475
ffb0b9b5b610191051a7bdf0806e1e47

Unusual stage 1 files apparently compiled from various public source codes merged with malicious code:

01c2f321b6bfdb9473c079b0797567ba
47d0e8f9d7a6429920329207a32ecc2e
744c07e886497f7b68f6f7fe57b7ab54
db405ad775ac887a337b02ea8b07fddc

Stage 1, 64-bit system infection:

bddf5afbea2d0eed77f2ad4e9a4f044d
c053a0a3f1edcbbfc9b51bc640e808ce
e63422e458afdfe111bd0b87c1e9772c

Stage 2, 32 bit:

18d4898d82fcb290dfed2a9f70d66833
b9e4f9d32ce59e7c4daf6b237c330e25

Stage 2, 64 bit:

d446b1ed24dad48311f287f3c65aeb80

Stage 3, 32 bit:

8486ec3112e322f9f468bdea3005d7b5
da03648948475b2d0e3e2345d7a9bbbb

Stage 4 32 bit:

1e4076caa08e41a5befc52efd74819ea
68297fde98e9c0c29cecc0ebf38bde95
6cf5dc32e1f6959e7354e85101ec219a
885dcd517faf9fac655b8da66315462d
a1d727340158ec0af81a845abd3963c1

Stage 4 64 bit:

de3547375fbf5f4cb4b14d53f413c503

Note: Stages 2,3 and 4 do not appear on infected systems as real files on disk. Hashes are provided for research purposes only.

Registry branches used to store malware stages 2 and 3:

- \REGISTRY\Machine\System\CurrentControlSet\Control\RestoreList
- \REGISTRY\Machine\System\CurrentControlSet\Control\Class\{39399744-44FC-AD65-474B-E4DDF-8C7FB97}
- \REGISTRY\Machine\System\CurrentControlSet\Control\Class\{3F90B1B4-58E2-251E-6FFE-4D38C5631A04}
- \REGISTRY\Machine\System\CurrentControlSet\Control\Class\{4F20E605-9452-4787-B793-D0204917CA58}
- \REGISTRY\Machine\System\CurrentControlSet\Control\Class\{9B9A8ADB-8864-4BC4-8AD5-B17DFDBB9F58}

C&C IPs:

61.67.114.73	Taiwan, Province Of China Taichung Chwbn
202.71.144.113	India Chetput Chennai Network Operations (team-m.co)
203.199.89.80	India Thane Internet Service Provider
194.183.237.145	Belgium Brussels Perceval S.a.

VFS RC5 decryption algorithm

This algorithm is used throughout the code and is referenced as RC5 in the document, although the implementation and the way the cipher is invoked is specific to Regin.

The implementation in C++ follows:

```
void       RC5Decrypt(uint8_t* rc5Key, uint8_t* data, size_t len)
{
           uint8_t        iv[8];
           rc5_ctx_t      ctx;
           uint8_t*       encrypted;
           size_t         encryptedLen;

           rc5_init(rc5Key, 128, 20, &ctx);
           memcpy(iv, data, 8);
           encrypted = data + 8;
           encryptedLen = len - 8;
           if ( encryptedLen % 8 )
           {
              uint8_t    ivLocal[8];
              if ( encryptedLen < 8)
                 memcpy(ivLocal, iv, 8);
              else
                 memcpy(ivLocal, encrypted + encryptedLen - (encryptedLen % 8) - 8, 8);
              rc5_enc(ivLocal, &ctx);
              for (size_t idx = 0; idx < (encryptedLen % 8); idx++)
                 encrypted[idx + encryptedLen - (encryptedLen % 8)] ^= ivLocal[idx];
           }
           if ( encryptedLen / 8 > 1 )
           {
              for (ssize_t blockIdx = (encryptedLen / 8) - 1; blockIdx > 0; blockIdx--)
              {
              rc5_dec(encrypted + blockIdx*8, &ctx);
              for (size_t idx = 0; idx < 8; idx++)
              encrypted[blockIdx*8 + idx] ^= encrypted[(blockIdx-1)*8 + idx];
              }
           }
           if ( encryptedLen / 8 > 0 )
           {
           rc5_dec(encrypted, &ctx);
           for (size_t idx = 0; idx < 8; idx++)
           encrypted[idx] ^= iv[idx];
           }
}
```

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