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Behavioral Matrix and Tool Analysis of Energetic Bear and GreyEnergy Actor

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Agenda

- **whoami**
- **Motivation**
- **Energy Sector Threats**
- **Behavioral Matrix Explanation**
- **Technical Tool Deep Dive**

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whoami

- Software Engineering Institute (SEI) CERT Coordination Center (CERT/CC)
  - Threat Analysis Directive -> Malware Analysis Team -> Reverse Engineering (RE) Team
- Adjunct Faculty & Faculty Advisor at Carnegie Mellon University and Adjunct Faculty at Duquesne University
- Develop and run the BSidesPGH Capture the Flag (CTF)
- Past work includes:
  - FireEye - Sr. Security Consultant dedicated to the SharkSeer Program
  - Private Consulting Firm - Digital Forensics and Incident Response
  - National Security Agency (NSA) - Various roles as a Technical Analyst
- Larger speaking engagements: Blackhat USA & Europe Arsenal, DEF CON, ShmooCon, NatCSIRT, Countermeasure, BSidesPGH, FIRST TC, Senate Cyber Threat Intelligence Summit
- Publications can be found on the SEI Digital Library and CERT/CC GitHub

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RE Team

The CERT/CC Reverse Engineering (RE) Team is committed being a world leader in advancing the art of malicious code analysis.

These include:

- Studying and analyzing the long or short term evolution of malware families
- Binary RE: Analysis and when appropriate YARA rule generation and/or the extraction of configuration data to include C2s, domains, username & password combinations, unique keys
- RE Tools: Create and maintain a suite of utilities to assist in and speed up the reverse engineering process
- RE Experience Beyond x86/x64: Experience in RE of other architectures and platforms such ARM, MIPS, PowerPC, and Android
- Hardware RE: firmware extraction and analysis

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Motivation

- Improve our corpus of knowledge on the RE Team
  - YARA rule and/or config dumper
- Identify gap areas of specific malware tools used by adversaries.
- How to do that?
  - Create a matrix that maps to internal and open source
  - Pick a piece of malware that has gaps in the matrix
  - YARA rule and/or config dumper

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Behavioral Matrix

- Fields
  - Malware Common Names
  - CERT/CC APIAnalyzer Behavior (if appropriate)
  - MITRE ATT&CK Techniques
  - CERT/CC Known YARA Rules
  - CERT/CC Config Dumper
  - OSINT YARA rules
- *This matrix will not only highlight internal gaps but also gaps that exist in the open source community*

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CERT/CC APIAnalyzer

- APIAnalyzer is a tool for finding sequences of API calls with the specified data and control relationships.
  - This capability is intended to be used to detect common operating system interaction paradigms like opening a file, writing to it, and the closing it.
- Part of Pharos static binary analysis framework
  - https://github.com/cmu-sei/pharos

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Energy Sector

- This time the focus is on the energy sector
- How many threat actors have been known to target the energy sector?
    - 20
- How many known tools?
    - Too many to count

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Caveat

- The following names and tools might NOT be exhaustive
- “Best know for” context when appropriate

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Russia

Energetic Bear

- *Other known names:* Dragonfly, Crouching Yeti, Group 24, Iron Liberty
- *Tools:* Havex/Oldrea, Sysmain, Trojan Heriplor/API Hashing Tool, Karagany, LightsOut Exploit Kit

Sandworm

- *Other known names*: Quedagh Group, Black Energy, Iridium
- *Tools:* W32/Industroyer, CrashOverride
- *Best known for:* NotPetya

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China

UPS

- *Other knows names*: Gothic Panda, APT 3, Group 6
- *Tools*: Shotput, Pirpi, PlugX/Sogu, Kaba, Cookie Cutter

Beijing Group

- *Other known names*: Sneaky Panda
- *Tools*: Hydraq, Elderwood Project
- *Best Known for*: Aurora Operation

C0d0so

- *Other known names*: APT 19, Sunshop Group
- *Tools*: Bergard Trojan, Derusbi, TXER

Hurricane Panda

- *Other known names*: APT 31, Black Vine
- *Tools*: China Chopper Webshell, PlugX, Mimikatz, Sakula

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China (continue)

Poisonous Panda

- *Other known names & Tools*: N/A

Violin Panda

- *Other known names*: APT 8, APT 20
- *Tools*: Poison Ivy, CAKELOG, CANDYCLOG, COOKIECLOG, CETTRA
- *Best known for*: Nitro Attacks

Wet Panda

- *Other known names*: N/A
- *Tools*: PlugX

Emissary Panda

- *Other known names*: LuckyMouse, TG-3390, APT 27
- *Tools*: PlugX, China Chopper Webshell, HttpBrowser

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Iran

Cutting Kitten

- *Other known names*: TG-2889
- *Tools*: TinyZBot, PupyRAT
- *Best known for*: Operation Cleaver

Shamoon

- *Other known names*: Volatile Kitten
- *Tools*: Shamoon/Disttrack

APT 33

- *Other known names*:
- Tools: SHAPESHIFT, DROPSHOT, TURNEDUP

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Iran (continue)

Magic Hound

- *Other known names*: Timberworm, MAGNALLIUM, Elfin
- *Tools*: Shamoon, POWERTON, PUPYRAT, POSHC2, TURNEDUP, Quasar RAT
- *Best known for*: Stronedrill/Shamoon 2.0

Rocket Kitten

- *Other known names*: Flying Kitten, Saffron Rose, Ajax Security Team, Group 26
- *Tools*: GHOLE/Core Impact, CWoolger, .NETWoolger, Puppy RAT, MagicHound.Leash

OilRig

- *Other known names*: Cobalt Gypsy, Twisted Kitten, Crambus, HELIX KITTEN, APT 34
- *Tools*: Helminth, ISMDoor, Clayslide, QUADAGENT, customized Mimikatz, POWBAT, POWRUNER

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Hacktivists

- Ghost Jackal
  - *Other known names*: N/A
  - *Tools*: web application exploitation, website defacement
- Corsair Jackal
  - *Other known names*: N/A
  - *Tools*: web application exploitation, website defacement

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Non Country Specific

Sea Turtle

- *Other known names*: N/A
- *Tools*: Target known vuls, spear phishing
- *Best known for*: DNS hijacking

GreyEnergy Group

- *Other known names*: N/A
- *Tools*: Maldoc, FELIXROOT/GreyEnergy Mini (Dropper), GreyEnergy Backdoor
- *Best known for*: “A successor to BlackEnergy”, critical infrastructure attacks

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Behavioral Matrix Exemplars

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Non Country Specific – GreyEnergy Group

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GreyEnergy Group

- Tool: FELIXROOT/GreyEnergy Mini (Dropper)

Malware Common Names	Actor Common Name	CERT APIAnalyzer Behavior	MITRE ATT&CK Techniques of Malware*	CERT Known YARA Rules	CERT Config Dumper	OSINT YARA Rules
FELIXROOT/GreyEnergy Mini (Dropper)	GreyEnergy	Informational: TerminateSelf Process Manipulation: CreateService, SpawnProcess	Code Signing, Command-Line Interface, Credential Dumping, File Deletion , Input Capture, Modify Existing Service, Modify Registry, Multi-hop Proxy, Obfuscated Files or Information, Process Injection, Remote File Copy, Rundll32, Software Packing, Standard Application Layer Protocol, Standard Cryptographic Protocol, System Service Discovery	No	Yes	Yes

* MITRE sees GreyEnergy as software and not a group

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Motivation

- Take a look at a group that specifically targeted the energy sector
- After reading a couple reports (ESET and Nozomi Networks) saw a challenge
- Challenge:
  - The reports were similar but didn't match – Nozomi Networks contained a specific workflow
    - Leverage the ESET report
  - Config dumper
    - Would only have results produced by config dumper if you execute the malware in a sandbox environment

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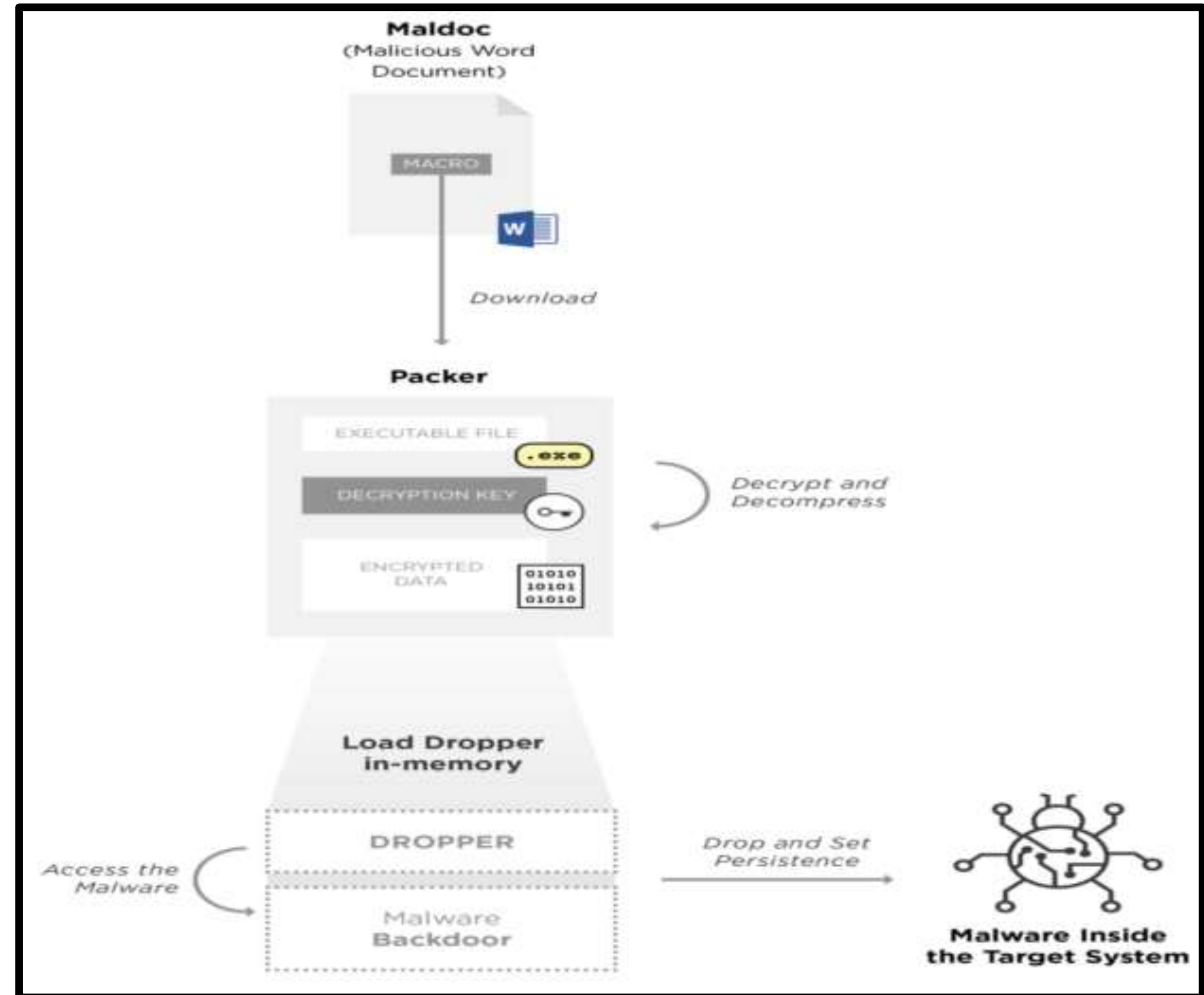
Attack Flow

1. Infection Vector: Maldoc
2. Stage 1: Packer
3. **Stage 2: Dropper**
4. Stage 3: Backdoor



Nozomi Networks Repot - GreyEnergy: Dissecting the Malware from Maldoc to Backdoor

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Dropper

- Leveraged the Nozomi Networks report (authored by Alessandro Di Pinto) analysis
- They wrote a YARA module and an unpacker tool
- The unpacker tool gives you the capability to get the dropper and the backdoor

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Dropper

- Focusing on the dropper
  - **Single execution of system**
  - **String obfuscation**
    - All the strings are obfuscated and stored in the .rdata section of the PE
      - This section is for read only data
      - This slows down analysis
    - The file obfuscates the strings with 8 byte XOR key
    - However, instead of utilizes only 4 of the 8 bytes of the key
    - *This made a nice situation for a config dumper*
  - **Memory wipe**
  - **Drop backdoor**

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Dropper

- **String obfuscation**
  - Strings are associated with what will be done with the dropped backdoor
    - File name of backdoor indicators
      - .db file extension which is a DLL
    - Persistence indicators
      - blank .lnk file pointing to rundll32.exe command
    - Execute backdoor
      - Executes the DLL with rundll32.exe
      - Cleans up traces of infection via shell: deletes and pings localhost
- Config dumper
  - Not everything in .rdata is a encoded string
  - Found 15 strings in the exemplars

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Analysis Process

- Analysis process – can be full automated
  1. Nozomi Networks GreyEnergy YARA module
  2. Nozomi Networks GreyEnergy Unpacker
     1. Dump both dropper and backdoor
  3. CERT/CC GreyEnergy Dropper Config Dumper
     1. Compare against previous TTPs

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Results

- Expanded corpus of analysis with the config dumper
- As a community urge for more detailed threat reporting
  - Meaning more clarification when defining malware types
  - Group vs. malware

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Russia – Energetic Bear

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Energetic Bear

- *Tool*: Trojan Heriplor/API Hashing Tool

Malware Common Names	Actor Common Name	CERT APIAnalyzer Behavior	MITRE ATT&CK Techniques of Malware	CERT Known YARA Rules	CERT Config Dumper	OSINT YARA Rules
Trojan Heriplor/API Hashing Tool	Energetic Bear, Dragonfly, Crouching Yeti, Group 24, IronLiberty	No results	Obfuscated Files or Information (Malware Attribute Enumeration and Characterization (MAEC) Project under: Anti Static Analysis (M9002)/Executable Code Obfuscation (E1027))	Yes	Yes	Yes

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Energetic Bear API Hashing Tool

- More of a story than the GreyEnergy Group analysis
- In the fall of 2018, the CERT/CC RE Team received a tip from a trusted source about a YARA rule (see below) they had been monitoring that alerted in VirusTotal
- YARA rule came from Department of Homeland Security (DHS) Alert TA17-293A
  - This document is associated with Russian activity.
- Current activity on year old signature == investigation

```
rule APT_malware_2
{
meta:
    description = "rule detects malware"
    author = "other"
strings:
    $api_hash = { 8A 08 84 C9 74 0D 80 C9 60 01 CB C1 E3 01 03 45 10 EB ED }
    $http_push = "X-mode: push" nocase
    $http_pop = "X-mode: pop" nocase
condition:
    any of them
}
```


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Energetic Bear API Hashing Tool

- The YARA rule (from the DHS report) was allegedly associated with the Energetic Bear group
- Energetic Bear, named by CrowdStrike, conducts global intelligence operations primarily against the energy sector.
- They have been in operation since 2012
- This intrusion set is also named Dragonfly (Symantec), Crouching Yeti (Kaspersky), Group 24 (Cisco), and Iron Liberty (SecureWorks), among others

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Analysis Methodology

- Analyzed the YARA rule and initial exemplar
- Created a tightly scoped YARA rule to discover new exemplars
- Discovered API hashes found in new exemplars
- Questioned attribution
- Attribution
- Results

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Analyzed the YARA rule and Initial Exemplar

- Understand the YARA
  - What do I think the variables represent?
- Specifically, interested in the *$api_hash* variable
- The variables *$http_post* and *$http_push* appeared to be associated with HTTP header fields
- Focused my analysis on the *$api_hash* variable

```
rule APT_malware_2
{
meta:
    description = "rule detects malware"
    author = "other"
strings:
    $api_hash = { 8A 08 84 C9 74 0D 80 C9 60 01 CB C1 E3 01 03 45 10 EB ED }
    $http_push = "X-mode: push" nocase
    $http_pop = "X-mode: pop" nocase
condition:
    any of them
}
```


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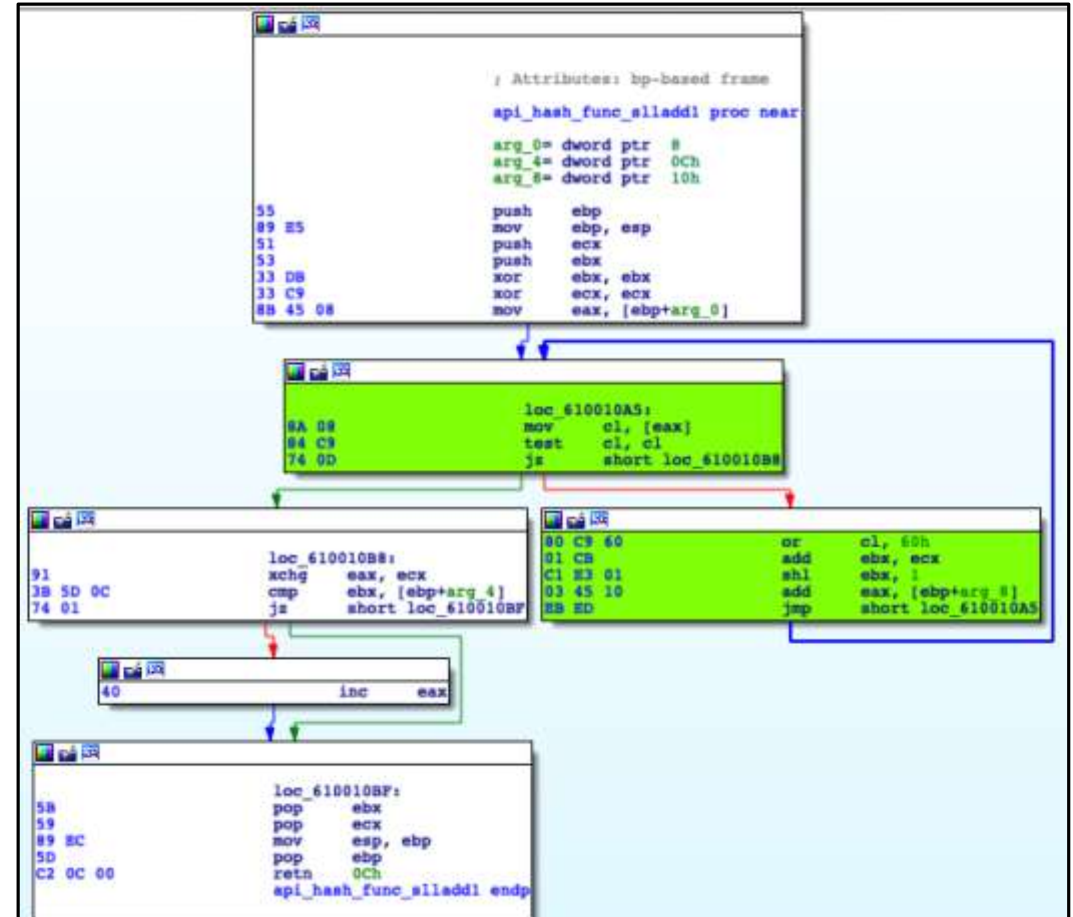
Analyzed the YARA rule and Initial Exemplar

- The *$api_hash* variable was alerting on the routine, highlighted in green
- The key points to highlight are the looping routine that contained an
  - *or* of 0x60,
  - *shift logical left (shl) by 1*,
  - followed by an *add*
- Hashing routine…Windows API hashing…?
  - YARA variable name helped



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Analyzed the YARA rule and Initial Exemplar

- Used the technical details of the previous API hashing routine and OSINT gathering, I found two items:
  - FireEye Flare IDA Plugins GitHub page that contained a plugin called *Shellcode Hashes*
  - FireEye blog post from 2012 titled “Using Precalculated String Hashes when Reverse Engineering Shellcode” which aided my understanding of API hashing
- In the FireEye Flare IDA plugin, *Shellcode Hashes* script, there was a similar routine that was mentioned on the last slide
  - *for loop* which contains an *or* of 0x60, followed by *add,* and a *shift left by 1*

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Things Known to this Point:

1. Exemplar uses API hashing technique that has been publicly seen before

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Analyzed the YARA rule and Initial Exemplar

- CERT/CC API hashing tool that creates a set of YARA signatures of API hashes for a given set of dynamic link library (DLL) files
  - This API hashing tool also contains a very similar function that matched the routine mentioned from the exemplar and the FireEye IDA plugin
- *Now I have 2 sources to back my findings based off of original YARA rule*
- Ran the CERT/CC API hashing tool on the exemplar for the specific *sll1Add* routine
  - Received an alert for kernel32.dll API hashes

Function	Byte Value (big endian)
LoadLibraryA	86 57 0D 00
VirtualAlloc	42 31 0E 00
VirtualProtect	3C D1 38 00

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Things Known to this Point:

1. Exemplar uses API hashing technique that has been publicly seen before
2. CERT has a tool that does API Hashing that includes this API hashing technique

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Analyzed the YARA rule and Initial Exemplar

- CERT/CC UberFLIRT ("kind of like FLIRT but Uber")
  - UberFLIRT calculates and stores PIC hashes of arbitrary functions, easily share information via a central database and has less false positives
  - Used with IDA
- Labeled the API hashing function shown in previous slides in IDA as *api_hash_func_slladd1* and saved it to the UberFLIRT database
  - This helps with analyzing potentially similar exemplars
- Examining the exemplar further:
  - Discovered 2 values that are passed as parameters to a function near entry point
  - The 2 values are 0x0038D13C and 0x000D4E88
    - The value 0x0038D13C is the hash of *VirtualProtect* which matches the values discovered by the CERT/CC API hashing tool on the previous slide
    - The other value, 0x000D4E88 is discussed next

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Analyzed the YARA rule and Initial Exemplar

- Examining this function further that took these 2 parameters:
  - Exemplar uses manual symbol loading techniques
    - Find symbols itself vs. using the Windows loader
  - Very similar to that of shellcode to find and load APIs
- This is where the API hash values come into play.
  - It's a way for the exemplar to obfuscate it's process
  - The 2 hashes we see first are to check the correct kernel32.dll (0x000D4E88) is being accessed and the second is for the first function, Virtual Protect (0x0038D13C), to utilize
  - Then the other functions, found as hashes in the exemplar, are checked and used
    - Will mention all the other functions later
- Labeled the function *manual_symbol_resolution* and saved it to the UberFLIRT database
  - This helps with analyzing potentially similar exemplars

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Things Known to this Point:

1. Exemplar uses API hashing technique that has been publicly seen before
2. CERT has a tool that does API Hashing that includes this technique
3. Labeled 2 functions using Uberflirt to help with future analysis
4. Exemplar using a technique typically used by shellcode
5. 2 initial hash values were identified - one for Virtual Protect, one for kernel32.dll name

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Created a Tightly Scoped YARA Rule to Discover New Exemplars

- Find new, but similar exemplars
- The following was my process to find additional exemplars:
  - Created API hash YARA rule to discover potential new exemplars
    - Used the CERT/CC MASS
  - Analyzed new exemplars for the presence of identified functions
    - *api_hash_func_slladd1* and *manual_symbol_resolution*
  - Created a tightly scoped YARA rule

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Created a Tightly Scoped YARA Rule to Discover New Exemplars

- CERT/CC Massive Analysis and Storage System (MASS)
  - In order to conduct research into executable code, we maintain a large archive of potentially malicious software artifacts
  - The archive consists of more than a billion artifacts collected from early 2005 until present day
  - The corpus of artifacts allows us, the analysts, to conduct research on how different malware families and threat actors have evolved over time

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Created a Tightly Scoped YARA Rule to Discover New Exemplars

- Using the MASS and this YARA rule to discover 36 new exemplars for a total of 37
- This YARA rule represents the *push* of the API hash value (0x0038D13C), *push* of the DLL hash value (0x000D4E88), and the *call* to *manual_symbol_resolution*
- I made an assumption that these 2 values were the 2 values always sent to the first function at the entry point of potential exemplars

```
rule api_hashes_2_call
{
  strings:
    (2019-02-22)
    $api_hashes_2_call = { 68 3C D1 38 00 68 88 4E 0D 00 E8 ?? ?? ?? ?? }
  condition:
    uint16(0) == 0x5a4d and $api_hashes_2_call
}
```


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Things Known to this Point:

1. Exemplar uses API hashing technique that has been publicly seen before
2. CERT has a tool that does API Hashing that includes this technique
3. Labeled 2 functions using Uberflirt to help with future analysis
4. Exemplar using a technique typically used by shellcode
5. 2 initial hash values were identified - one for Virtual Protect, one for kernel32.dll name
6. Created specific YARA rule and identified 36 more exemplars

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Created a Tightly Scoped YARA Rule to Discover New Exemplars

- Wanted to make sure I really had new exemplars
- Refined the original YARA rule (from DHS report)
- Realized that some of the new exemplars did not alert with this refined YARA rule
- Analyzed this subset of new exemplars that did not hit
  - discovered two slight variations in the API hashing function
- The first was an addition of 1 extra byte
- The second dealt with 64-bit files

```
rule energetic_bear_api_hashing_tool {
meta:

    description = "Energetic Bear - API Hashing"
    assoc_report = "DHS Report TA17-293A"
    author = "CERT RE Team"
    version = “1”

strings:
    $api_hash_func = { 8A 08 84 C9 74 0D 80 C9 60 01 CB C1 E3 01 03 45 10 EB ED }
    $http_push = "X-mode: push" nocase
    $http_pop = "X-mode: pop" nocase

condition:
  $api_hash_func and (uint16(0) == 0x5a4d or $http_push or $http_pop)
```


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Created a Tightly Scoped YARA Rule to Discover New Exemplars

- Refined the YARA rule further to incorporate these two variations, for a total of 3 variations

```
rule energetic_bear_api_hashing_tool {
meta:
    description = "Energetic Bear API Hashing Tool"
    assoc_report = "DHS Report TA17-293A"
    author = "CERT RE Team"
    version = “2”

strings:
    $api_hash_func_v1 = { 8A 08 84 C9 74 ?? 80 C9 60 01 CB C1 E3 01 03 45 10 EB ED }
    $api_hash_func_v2 = { 8A 08 84 C9 74 ?? 80 C9 60 01 CB C1 E3 01 03 44 24 14 EB EC }
    $api_hash_func_x64 = { 8A 08 84 C9 74 ?? 80 C9 60 48 01 CB 48 C1 E3 01 48 03 45 20 EB EA }

    $http_push = "X-mode: push" nocase
    $http_pop = "X-mode: pop" nocase

condition:
    $api_hash_func_v1 or $api_hash_func_v2 or $api_hash_func_x64 and (uint16(0) == 0x5a4d or $http_push or $http_pop)
}
```


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Things Known to this Point:

1. Exemplar uses API hashing technique that has been publicly seen before
2. CERT has a tool that does API Hashing that includes this technique
3. Labeled 2 functions using Uberflirt to help with future analysis
4. Exemplar using a technique typically used by shellcode
5. 2 initial hash values were identified - one for Virtual Protect, one for kernel32.dll name
6. Created specific YARA rule and identified 36 more exemplars
7. Refined original YARA rule to cover 3 variations

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Discovered API Hashes Found in New Exemplars

- Identified *sll1Add* routine API hash values found in all of the 37 exemplars
- All exemplars had API hash values for functions from kernel32.dll
- Most of the exemplars had *sll1Add* routine API hash values for functions from ws2_32.dll
- There were a few outliers that had *sll1Add* routine API hash values for functions form wininet.dll

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Discovered API Hashes Found in New Exemplars

- Use of functions from ws2_32.dll and wininet.dll demonstrates that these exemplars have potential network communications
  - The use of two different DLLs for network communications draws conclusions to the existence of at least 2 different versions of the API hashing tool
- Further analyzed the exemplars to identify any network-based IOCs
- 33 of 37 exemplars, identified 29 unique IP address and port combinations

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Discovered API Hashes Found in New Exemplars

- 4 of 37 the exemplars had structure outbound POST request.
- For 2 of these 4, I captured the requests in a pcap using FakeNet

```
POST / HTTP/1.1
X-mode: pop
X-id: 0x00000000,0x5547a48a
User-Agent: Mozilla
Host: 187.234.55.76:8080
Content-Length: 0
Connection: Keep-Alive
Cache-Control: no-cache
```

- Inferred the outbound POST request structure from strings for the remaining 2

```
X-mode: push\r\nX-type: more\r\nX-id:
0x00000000,0x523fe61c\r\n
X-mode: push\r\nX-type: last\r\nX-id:
0x00000000,0x523fe61c\r\n
X-mode: pop\r\n\r\nX-id: 0x00000000,0x523fe61c\r\n
Mozilla
POST
```

- You can build Snort signatures for this traffic

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Things Known to this Point:

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3. Labeled 2 functions using Uberflirt to help with future analysis
4. Exemplar using a technique typically used by shellcode
5. 2 initial hash values were identified - one for Virtual Protect, one for kernel32.dll name
6. Created specific YARA rule and identified 36 more exemplars
7. Refined original YARA rule to cover 3 variations
8. Identified all API hash values present in all of the exemplars
9. Identified 2 additional versions based on network comms
10. Identified additional IOCs

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Questioned Attribution

- Tried to identify other public reporting or research related to this Energetic Bear API hashing tool
- I did not find any reporting or research

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Questioned Attribution

- Since there was a link to Energetic Bear, I thought it could be a remote access trojan (RAT) like Havex, which is also attributed to this particular group
- Decided to explore the potential RAT association
- Discovered research by Veronica Valeros on "A Study of RATs: Third Timeline Iteration"
  - Contacted her directly and ask if she recalled any of the RATs use an API hashing technique
  - She could not recall, but mentioned that it could have been missed because she was not explicitly looking for this technique.
- Used her research to attempt to identify more RATs that use an API hashing technique
- <u>I have not found any that use this technique</u>

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Attribution

- The power of open source sharing has been positive
- It was brought to my attention (thanks to Matt Brooks from Citizen Lab) that this API hashing tool is related to Trojan.Heriplor from Symantec’s Dragonfly report
- The hash in Symantec's report is, in fact, one of the exemplars
  - Symantec provided this hash in the form of a picture, and I must have fat-fingered the hash when transcribing it
  - However, this specific API hashing technique isn't mentioned in their report
- Symantec's Trojan.Heriplor analysis attributes my analysis of this API hashing tool to Energetic Bear
- More importantly, this linkage also shows that this tool is still actively used
  - Most recent hit on my YARA in VirusTotal was June 3rd

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Results

- I hope by publicly discussing that analysis that I can encourage information sharing and allow us, as a community, to urge for more detailed threat reporting
  - i.e. no pictures of hashes ¯_(ツ)_/¯
- Have spoken to the MITRE ATT&CK team and the Malware Attribute Enumeration and Characterization (MAEC™) team
  - API Hashing has been added to their Malware Behavior Catalog Matrix
  - You can find the API Hashing listed as an Executable Code Obfuscation method under the Anti-Static Analysis behavior
- Complete analysis on blog which includes YARA rule and IOCs
- YARA rule can also been found in Florian Roth's Signature Base on GitHub
- My analysis and attribution alignment makes this report (blog) the **first** publicly documented report of API hashing technique being used by a nation state actor

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Contact Information

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Contact me directly for GreyEnergy Dropper Config Dumper

Blog post on SEI website titled “*API Hashing Tool, Imagine That*”
https://insights.sei.cmu.edu/cert/2019/03/api-hashing-tool-imagine-that.html

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References

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