“egg” – A Stealth fine grained code analyzer

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Agenda

• Background and problems
• Introduce “egg”
  – Demonstration its basic functions
• Implementation (Taint tracing approach in ring-0)
  – Demonstration of the taint tracing behavior
• Discuss a limitation of “egg”
• Conclusion
Too many malwares!

The percentage of packed malwares

80% of malwares ware packed in 2007

- We can’t manually analyze each malware.
- Automatic approaches have become more important.

Source:
2001-2005: McAfee Sage vol.1 issue 1
2007: Panda Research (http://research.pandasecurity.com/malwareformation-statistics/)
Problems of traditional dynamic analyzers

- We can’t get useful information for more intensive analysis.
- We can’t analyze a kernel mode code.
- It’s difficult to analyze a spreading malware over the process.
Innovative analyzers (based on VM environments)

- Innovative analyzers have already resolved the above problems 😊
  - Anubis
  - Ether
    - It’s able to analyze a kernel mode code and perform an instruction level analysis.
  - BitBlaze and Renovo
    - Also these analyze a spreading malware automatically with approach called “taint tracing”.

- However these systems are detected by VM detection techniques 😞
Summary table of problems

<table>
<thead>
<tr>
<th>Type of system</th>
<th>Traditional</th>
<th>Innovative (Based on virtual environments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting useful information</td>
<td>Insufficient</td>
<td>Good</td>
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- I developed “egg” to try and resolve these problems.
What is egg?

- “egg” is a dynamic analyzer based on a Windows device driver.

- egg has following capabilities:
  1. It can obtain more detailed information.
  2. It can analyze a kernel mode code.
  3. It can automatically trace a spreading malware.

- Of course, It’s not affected by VM detection techniques.
- Also most common anti-debug tech can’t detect “egg”.
What kind of information does ”egg” collect?

1. API arguments for IN, OUT (,INOUT), and return value

```c
BOOL WINAPI ReadFile(
    __in         HANDLE hFile,
    __out        LPVOID lpBuffer,
    __in         DWORD nNumberOfBytesToRead,
    __out_opt    LPDWORD lpNumberOfBytesRead,
    __inout_opt  LPOVERLAPPED lpOverlapped
);
```
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call to kernel32.dll!ReadFile(
    Arg 1 : 00000064 = File : ¥Device¥HarddiskVolume1¥WINDOWS¥(...)
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Call to kernel32.dll!ReadFile(
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    Arg 3 : 00000800(2048)
)

Returned from kernel32.dll!ReadFile(
    Arg 2 : 0012F184 - 0012F983 is dumped as ¥(...)(...)ReadFile_Arg02.bin
) => 00000001(1)
What kind of information does "egg" collect?

2. Callgraph
3. Branch information
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Demonstration of basic functions (movie)

- Analyzing sample.exe.

- Sample.exe overwrites original beep driver (beep.sys).
- Then restarts beep service to install this driver in the kernel.

- “egg” analyzes sample.exe and the modified beep driver.
Implementation of the fine-grained code analysis

• Based on the page protection and the trap flag.
• Published by the paper “Stealth Breakpoints”.

• We can run analysis codes for each instruction execution.
• It can applies to both a kernel and user modes, and even works transparently in the user mode code.

Stealth Breakpoints
http://www.acsac.org/2005/abstracts/72.html
What is taint tracing?

- It can automatically trace suspicious elements.
- A suspicious element is marked as tainted.
- A taint automatically influences new elements that used tainted elements.

Some suspicious sources

![Diagram showing taint tracing process]
An overview of taint tracing approach of “egg”

- egg takes a novel approach to implement the taint tracing.
- In case of egg, “Elements” are Files, Virtual memory and Threads.
An overview of taint tracing approach of “egg”

- egg takes a novel approach to implement the taint tracing.
- In case of egg, “Elements” are Files, Virtual memory and Threads.
Implementation of taint tracing in ring-0

1. Specify
2. Map in Mem
3. Execute
4. Write to File
4. Write to Mem

Using API
PsSetLoadImageNotifyRoutine
Implementation of taint tracing in ring-0

Using the page protection (eXecute Disable bit)

1. Specify
2. Map in Mem
3. Execute
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Using the page protection (eXecute Disable bit)
Implementation of taint tracing in ring-0

1. Specify

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Using the File system filter driver
Implementation of taint tracing in ring-0

Using the page protection (Write/Read bit)

1. Specify
2. Map in Mem
3. Execute
4. Write to Mem
4. Write to File

Taint File
Taint Memory
Thread
Taint File
Taint Memory
Implementation of taint tracing in ring-0

- For thread safety, egg hooks thread switching function (called SwapContext).
- Therefore egg can notice a thread switching.

Process memory has not been modified yet.
Implementation of taint tracing in ring-0

- When taint thread becomes active, egg changes every process memory to read-only.

Currently, process memory is read-only.

If a thread tries to write somewhere, the processor causes an exception. egg catches this exception as taint event.
Implementation of taint tracing in ring-0

- When taint thread becomes inactive, egg restores every page protection.

Process memory protection is restored.
Tracking the cross-process memory operation

- To trace cross-process memory operation, egg hooks context switching function (called KiSwapProcess).
- Therefore egg can notice cross-process memory operation.
Tracking the cross-process memory operation

- When taint thread is running on other process memory, its process memory will be changed to read-only.

egg can trace cross-process memory operation. (e.g. WriteProcessMemory)
Demonstration of the taint tracing function (movie)

- The sample is the thread injection code.

- Sample malware called “injector.exe” injects to notepad.exe with VirtualAllocEx, WriteProcessMemory and CreateRemoteThread.

- Injected thread calls AllocConsole and WriteConsole in infinite loop.

- egg will trace the injected thread.
Problem of same privilege

- egg has limitation against kernel mode code.
  - egg is visible and breakable from kernel mode malware.

- This limitation is result of trade off for avoiding detection by the VM detection.
Conclusion

- We can save time by using egg.
- In the future, I will try to improve its stability and usability.

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