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恶意代码分析与防治技术

第14章：恶意代码网络行为分析

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2023-2024学年



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王水 | 期末考试监考巡考安排待核对

老师们好，本学学期期末考试监考、巡考安排请见附件，如有时间不合适的老师请在本周内（12.8下班前）将调换好的信息告知我，非常感谢您





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星标联系人邮件

'Cavallaro, Lorenzo'

草稿箱 (1)

已发送

订阅邮件

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广告邮件

垃圾邮件 (40)

Notes

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发件人: 南开大学党委网信办<admin@baidukar.info>

收件人: 我<zwang@nankai.edu.cn>

时间: 2023年12月09日 03:53 (星期六)

亲爱的用户:

我们向您发送此电子邮件是为了提醒您, 根据我们的安全政策, 您的账户口令已经过期。为了保护您的账户安全, 我们强烈建议您立即更新口令。

请您立即访问以下地址更新您的口令, 否则您将无法登录访问您的账户:

地址: <https://nankai.edu.cn/>

在该地址输入您的账户用户名、当前口令和新口令。

确认新口令, 并保存更改。

请注意, 如果您不尽快更新口令, 您将无法正常登录访问您的账户, 可能会存在安全风险, 包括未经授权的访问和信息泄露。

为了确保您的账户安全, 请遵循以下密码设置建议:

(1) 使用至少8个字符的复杂口令, 包括大写字母、小写字母、数字和特殊字符。

(2) 避免使用与个人信息相关的口令, 如姓名、生日、电话号码等。

(3) 定期更改口令, 避免重复使用之前使用过的口令。

(4) 不要将口令透露给他人, 包括我们的工作人员。

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Not secure | 47.97.21.99:8081/outer/web/47... | d=eNqrVspNzMyJL8kvScxRslIwMzcw1FFQSkxJKUotLgYKKFWVJ-aIO-Ql5mUnZuqlppTqJecpAVXkJeamgqRjSk2NTc2BZJqBAZC0NAKxk8zMlGoBEqM...

Overleaf | GitHub | NKU | Prof | RHUL | Malware | ML | Bin | 翻译 | 知乎 | 百度 | dblp | Twitter | YouTube | Maps | ORCID | #393 | 腾讯文档 | TDS | TIFS | Gepetto | nkamg | ssdeep | All Bookmarks



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热点问题 | 使用帮助 | 在线客服 | 意见建议

欢迎登录南开大学电子邮箱系统

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教工邮箱

学生邮箱

请输入用户名

请输入密码

☐记住用户名 ☒SSL安全登录 ☐全程SSL

登录

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网络钓鱼（Phishing）

关于收到“关于系统密码过期请及时更新的通知”邮件的注意事项

发件人: 南开大学党委网信办<wxh@nankai.edu.cn>

收件人: 我<zwang@nankai.edu.cn>

时 间: 2023年12月13日 11:37 (星期三)

老师，您好！

如果您收到该邮件，代表您未识别出此次钓鱼邮件，邮件主题为：“关于系统密码过期请及时更新的通知”，这是学校开展的钓鱼邮件应急演练，请您不必担心，务必阅读以下内容提高防范意识。

本次钓鱼邮件为测试邮件，只统计点击提交次数用于数据分析，不会对电脑、邮箱等个人信息造成任何影响。

提高网络安全防范意识，加强钓鱼邮件防范，提升甄别能力，尤其对邮件发件人、邮件中不明链接及附件需要反复确认，切勿轻易点击不明邮件、未知链接等，谨慎下载运行可疑程序和文件。

防范钓鱼邮件“五要”、“五不要”：

- 1、防毒软件要安装、不要轻信发件人地址中显示的“显示名”(可伪造)。
- 2、登录密码要保密、不要将敏感信息发布在互联网上。
- 3、邮箱账号要绑定手机、不要轻易点开陌生邮件中的链接（木马多）。
- 4、公共私人邮箱要分清、不要放松对”熟人”邮件的警惕。
- 5、重要文件要做好防护、不要使用公共场所的网络设备执行敏感操作。

如您对本次钓鱼邮件演练有任何疑问，可联系党委网信办23509595，工作人员会耐心解答您的疑惑。



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本章知识点

- 网络应对措施（Network Countermeasures）
- 网络事件调查（Safely Investigate an Attacker Online）
- 基于内容的防治（Content-Based Network Countermeasures）
- 动静结合分析（Combining Dynamic and Static Analysis Techniques）
- 攻击者角度分析（Understanding the Attacker's Perspective）



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网络应对措施 Network Countermeasures

针对恶意代码的网络行为，目前有哪些检测工具？

正常使用主观题需2.0以上版本雨课堂

作答



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Common Network Countermeasures

- 防火墙、路由器（Filtering with firewalls and routers）
 - By IP address, TCP and UDP ports
- DNS服务器（DNS Servers）
 - Resolve malicious domain names to an internal host (a *sinkhole*)
 - DNS sinkhole
- 代理服务器（Proxy servers）
 - Can detect or prevent access to specific domains



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网络数据

- IP地址
- TCP和UDP的端口号（ports）
- 域名（domain names）
- 数据包（traffic content）



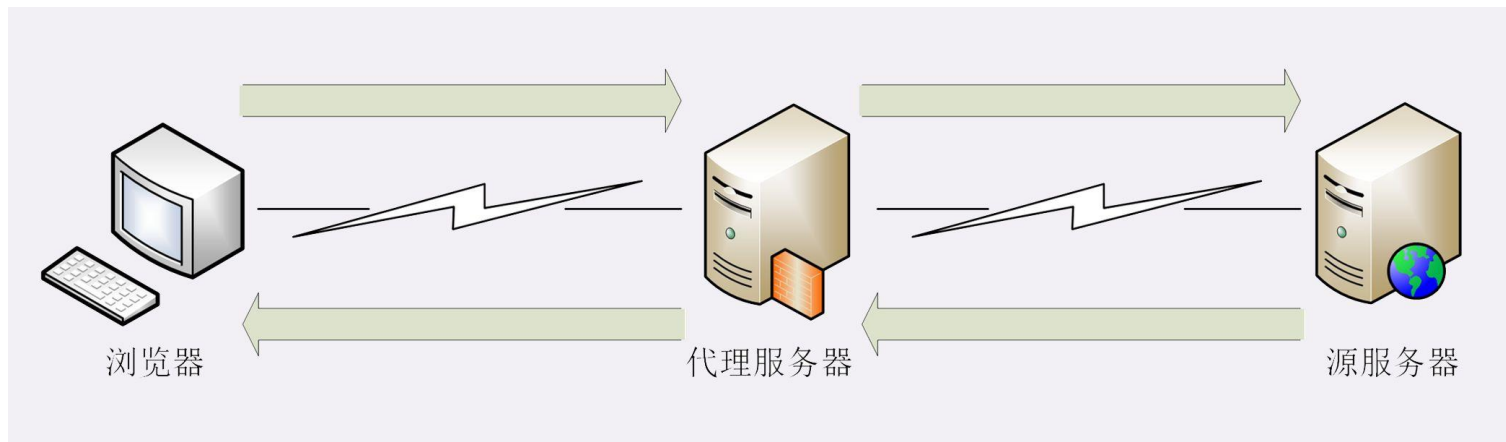
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DNS沉洞（DNS Sinkhole）

- **DNS沉洞**技术（DNS Sinkhole、网络沉洞、沉洞服务器、黑洞DNS）是指在网络中的某一域名被判定为恶意域名后，由安全厂商或运营商将其原本解析到的IP地址变更到无害IP地址的技术。
 - **检测、阻挡**有害流量、自动程序以及不需要的流量，例如控制WannaCry病毒的蔓延、打击僵尸网络；
 - **监测**当前已经失陷的主机数量和状态

代理服务器 (Proxy server)

- 代理服务器 (Proxy Server) 用来代理用户去取得网络信息
 - 网络信息的中转站
 - 多用户、缓存、监控、过滤





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Content-Based Countermeasures

- 深度数据包检测（DPI, Deep Packet Inspection）
 - 入侵检测系统（IDS, Intrusion Detection System）
 - 入侵防御系统（IPS, Intrusion Prevention System）
 - 邮件代理（Email Proxy）
 - Web代理（Web Proxy）



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讨论：入侵检测系统IDS和入侵防御系统IPS有什么区别？

作答

IDS vs IPS

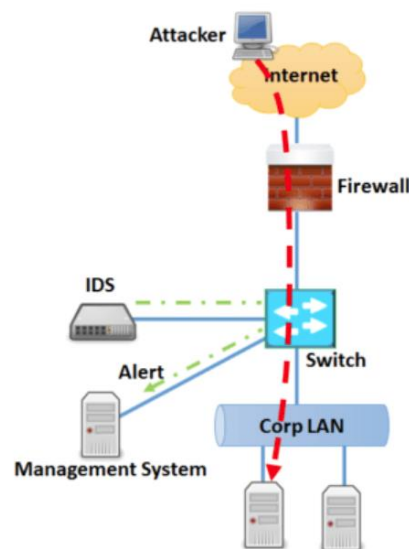
- 入侵检测系统 (IDS)

- 被动监听网络数据，旁路部署
- 检测可疑或恶意流量

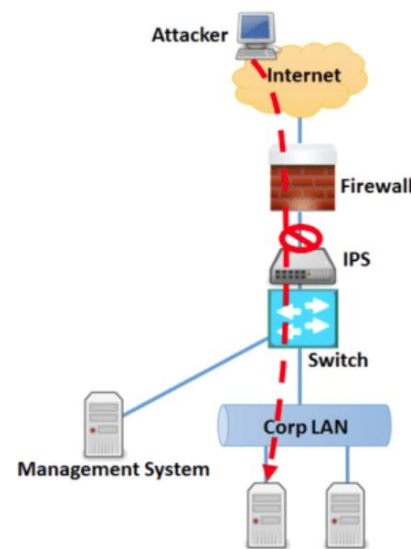
- 入侵防御系统 (IPS)

- 主动过滤网络数据，串联部署
- 所有流量都必须通过该设备才能继续到达目的地
- 检测到恶意流量后，IPS 会中断连接并丢弃会话或流量

Intrusion Detection System



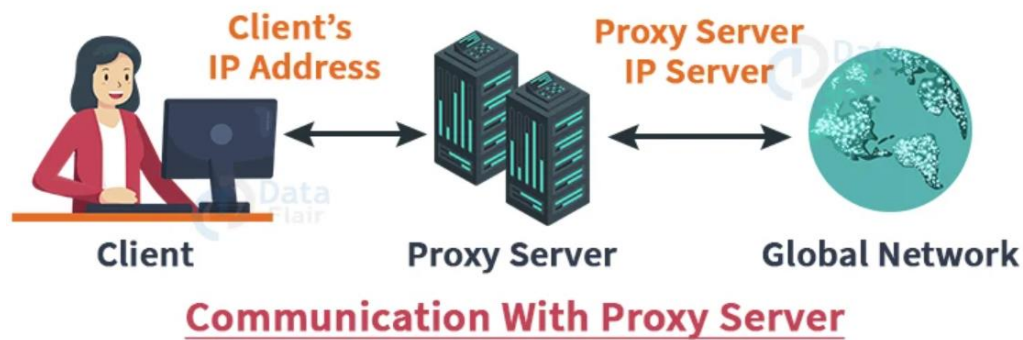
Intrusion Prevention System



代理服务器

- Email Proxy
- Web Proxy

Mechanism of Proxy Server





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Observing the Malware in Its Natural Habitat

- Before static or dynamic analysis
- Mine **logs**, **alerts**, and **packet** captures generated by malware in its original location



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真实环境 vs. 实验室环境

- Live-captured data is the most accurate
 - Some malware detects lab environments
- Real traffic contains information about both ends (双向网络流量)
 - infected host and C&C server
- Passively monitoring traffic is more **stealthy**
 - OPSEC (Operational Security)



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Indications of Malicious Activity

Table 15-1. Sample Network Indicators of Malicious Activity

Information type	Indicator
Domain (with resolved IP address)	www.badsite.com (123.123.123.10)
IP address	123.64.64.64
GET request	GET /index.htm HTTP 1.1 Accept: */* User-Agent: Wefa7e Cache-Control: no





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OPSEC

- 运营安全（OPSEC）
- OPSEC是风险管理中使用的一种策略，从竞争对手或敌人的角度查看操作或项目。
- If attackers are aware of investigation, attackers may change tactics and effectively disappear.



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OPSEC

- Preventing adversaries from obtaining sensitive information
- Running malware at home may alert attackers
 - Who expected it to be run in a company
- Investigate vs. Reveal
 - Different from advance static analysis
 - Reveal personal details about investigator to the attacker. (个人信息泄露)





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Identify Investigative Activity

- Send **spear-phishing email** with a link to a specific individual
 - Watch for access attempts outside the expected geographic area
- Design an **exploit** that logs infections
 - In a blog comment, Twitter, etc.
- Embed an **unused domain** in malware
 - Watch for attempts to resolve the domain





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Safely Investigate an Attacker Online

如何避免在分析恶意代码的过程中被攻击者发现？

正常使用主观题需2.0以上版本雨课堂

作答



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间接策略 (Indirection Tactics)

- Proxy server, Tor, Web-based **anonymizer**
 - Not subtle—it's obvious that you are hiding
- Use a dedicated **VM** for research
 - Hide its location with a cellular or VPN connection
- Use an **ephemeral** cloud machine
 - Such as an Amazon E2C virtual machine



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搜索引擎Search Engines

- Usually safe
- If the domain was previously unknown to the search engine, it may be crawled
- Clicking results still activates secondary links on the site
 - Even opening cached resources





Getting IP Address and Domain Information

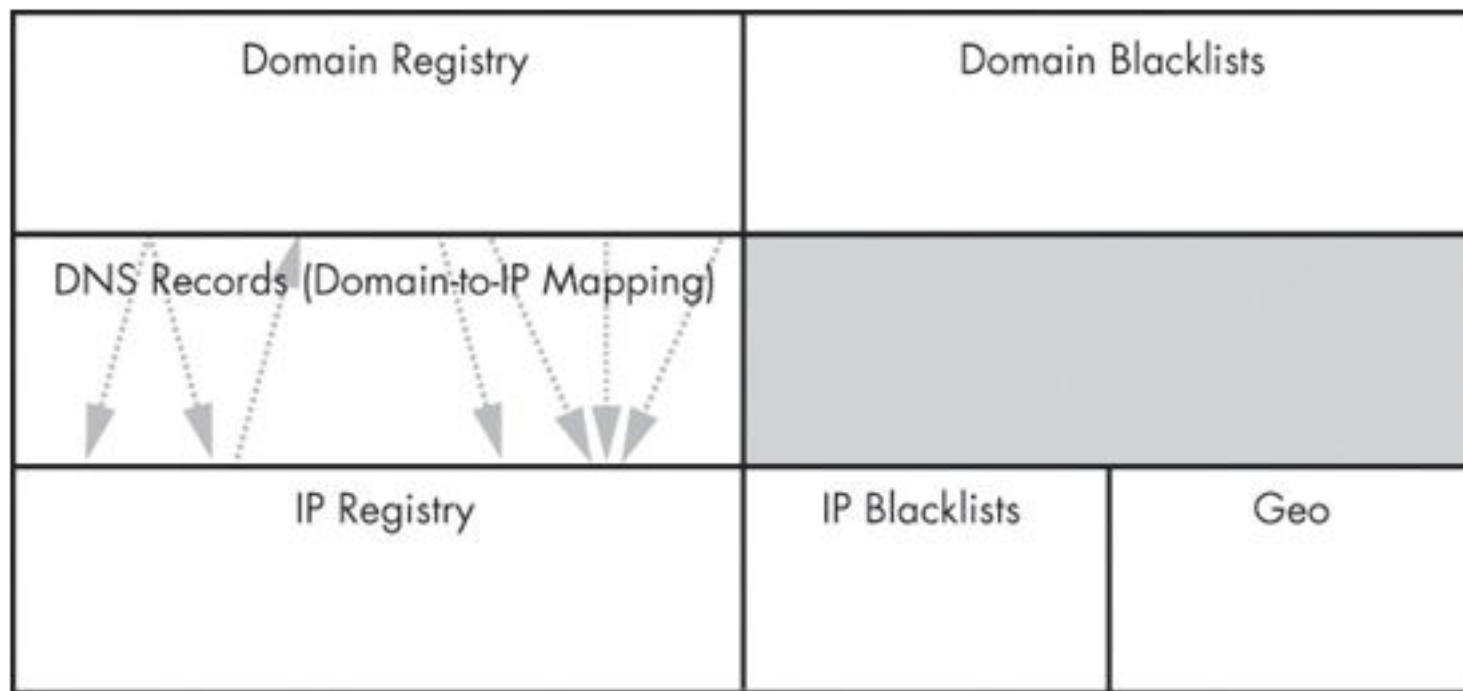


Figure 15-1. Types of information available about DNS domains and IP addresses



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Command-Line vs. Web-Based Lookups

- Command-Line
 - **whois** and **dig** can be used, but they will expose your IP address
- Web-Based
 - Websites that do the query for you provide anonymity
 - May give more information





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RobTex

- Finds multiple domain names that point to a single IP address
- Checks blacklists

QUICK INFO	
Quick summary of the host name	
cyber.nankai.edu.cn quick info	
General	
FQDN	cyber.nankai.edu.cn
Host Name	cyber
Domain Name	nankai.edu.cn
Registry	edu.cn
TLD	cn
Domain DNS	
Name servers	dns.nankai.edu.cn dns1.nankai.edu.cn dns2.nankai.edu.cn
Mail servers	hzm01.mxmail.netease.com hzm02.mxmail.netease.com
IP Numbers	202.113.16.33
REVERSE (NEW!)	





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VirusTotal



Analyze suspicious files and URLs to detect types of malware, automatically share them with the security community

FILE

URL

SEARCH



Search or scan a URL

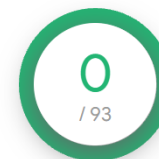


By submitting data above, you are agreeing to our [Terms of Service](#) and [Privacy Policy](#), and to the sharing of your URL submission with the security community. Please do not submit any personal information; VirusTotal is not responsible for the contents of your submission. [Learn more](#).

① Want to automate submissions? [Check our API](#), free quota grants available for new file uploads



http://www.nankai.edu.cn/



✓ No security vendors flagged this URL as malicious

http://www.nankai.edu.cn/

www.nankai.edu.cn

?

Community Score

DETECTION

DETAILS

COMMUNITY

Categories ①

Forcepoint ThreatSeeker	educational institutions
Sophos	educational institutions
BitDefender	education

History ①

First Submission	2014-05-20 10:51:24
Last Submission	2021-12-07 22:17:00
Last Analysis	2021-12-07 22:17:00



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Content-Based Network Countermeasures

网络流量中有哪些内容（content）可以用来检测恶意代码的网络行为？

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作答



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Intrusion Detection with Snort

- Rule-based detection, can use:
 - TCP or IP headers
 - Size of payload
 - Connection state (such as ESTABLISHED)
 - Layer 7 payload data



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Snort Rule to Block HTTP Traffic by User-Agent

```
alert tcp $HOME_NET any -> $EXTERNAL_NET $HTTP_PORTS (msg:"TROJAN Malicious User-Agent";  
content:"|0d 0a|User-Agent\: Wefa7e"; classtype:trojan-activity; sid:2000001; rev:1;)
```

Table 15-2. Snort Rule Keyword Descriptions

Keyword	Description
---------	-------------

msg	The message to print with an alert or log entry
content	Searches for specific content in the packet payload (see the discussion following the table)
classtype	General category to which rule belongs
sid	Unique identifier for rules
rev	With sid, uniquely identifies rule revisions





Taking a Deeper Look

- Running the malware several times shows these User-Agent strings
- Rules can be fine-tuned to capture the malware without false positives

We4b58	We7d7f	Wea4ee
We70d3	Wea508	We6853
We3d97	We8d3a	Web1a7
Wed0d1	We93d0	Wec697
We5186	We90d8	We9753
We3e18	We4e8f	We8f1a
Wead29	Wea76b	Wee716





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Combining Dynamic and Static Analysis Techniques

如何进一步提升恶意代码网络行为的特征质量，例如特征的准确度和持续性？

(more accurate and longer-lasting signature)

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作答



Two Objectives of Deeper Analysis

- Full **coverage** of functionality using dynamic analysis
 - Provide new inputs to drive the malware down unused paths
 - Using iNetSim or custom scripts
- **Understanding** functionality, including inputs and outputs
 - Static analysis **finds** where and how content is generated
 - Dynamic analysis **confirms** the expected behavior



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Effective and Robust Signature

- Differentiate between **regular traffic** and the **traffic associated with malware**
- Why this is a big challenge ?
- The evolution of malware is rapid.
 - Mimic Existing Protocols, Use Existing Infrastructure, Leveraging Client-Initiated Beaconsing



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Hiding in Plain Sight

- Attackers mimic existing protocols
 - Often **HTTP**, **HTTPS**, and **DNS**, no more IRC
 - HTTP for beaconing (request for instructions)
 - HTTPS hides the nature and intent of communications
 - Information can be transmitted in DNS requests
 - For example, in long domain names
 - `www.thepasswordisflapjack.maliciousdomain.com`.





GET and POST

- GET for request
- POST for send
- Used to send a command prompt followed by a directory listing

```
GET /world.html HTTP/1.1
User-Agent: %^&NQvtmw3eVhTfEBnzVw/aniIqQB6qQgTvmxJzVhjQJMjcHtEhI97n9+yy+duq+h3
b0RFzThrfE9AkK90YIt6bIM7JUQJdViJaTx+q+h3dm8jJ8qfG+ezm/C3tnQgvVx/eECBZT87NTR/fU
QkxmGcGLq
Cache-Control: no-cache

GET /world.html HTTP/1.1
User-Agent: %^&EBTaVDPYTM7zVs7umwvhTM79ECrrmd7ZVd7XSQFvV8jJ8s7QVhcgVQ0q0hPdUQB
XEAKgVQFvms7zmd6bJtSfHNSdJNEJ8qfGEA/zmwPtnC3d0M7aTs79KvcAVhJgVQPZnDIqSQkuEBJvn
D/zVwneRAyJ8qfGIN6aIt6aIt6cI86qI9mLIe+q+OfqE86qLA/F0tjqE86qE86qE86qHqfGIN6aIt6
aIt6cI86qI9mLIe+q+OfqE86qLA/F0tjqE86qE86qE86qHsJ8tAbHeEbHeEbIN6qE96jKt6kEABJE
86qE9cAMPE4E86qE86qE86qEA/vmhYfVi6J8t6dHe6cHeEbI9uqE96jKtEkEABJE86qE9cAMPE4E86
qE86qE86qEATrnw3dUR/vmbfGIN6aINAAIt6cI86qI9uLJNmQ+OfqE86qLA/F0tjqE86qE86qE86qN
Ruq/C3tnQgvVx/e9+ybIM2eIM2dI96kE86cINygK87+NM6qE862/AvMLS6qE86qE86qE87NnCBdn87
JTQkg9+yqE86qE86qE86qE86bEATzVC0ymduqE86qE86qE86qE86qE96qSxvfTRIj8s6qE86qE
86qE86qE86qE9Sq/CvdGDIzE86qK8bgIeEXItObH9SdJ87s0R/vmd7wmwPv9+yJ8uILRA/aSiPYTQk
fmd7rVw+q0hPfnCvZTiJmMtj
Cache-Control: no-cache
```



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User Agents

- Early malware used **strange User-Agent strings**
- This made it easy to block
- Valid user agent:

```
Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1; .NET CLR 2.0.50727;  
.NET CLR 3.0.4506.2152; .NET CLR 3.5.30729; .NET4.0C; .NET4.0E)
```





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3 Possible User Agents

- Malware alternates between these to defeat detection

```
Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1)  
Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.2)  
Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.2; .NET CLR 1.1.4322)
```





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Use Existing Infrastructure

- A server only servicing malware requests, it will be more vulnerable to detection
- Use a server used for **legitimate purposes** to cloak malicious uses.
 - Investigation of the IP address will also reveal the legitimate uses.





Attackers Use Existing Infrastructure

- Botnet commands concealed in source code of a Web page

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title> Roaring Capital | Seed Stage Venture Capital Fund in Chicago</title>
<meta property="og:title" content=" Roaring Capital | Seed Stage Venture Capital Fund in Chicago"/>
<meta property="og:site_name" content="Roaring Capital"/>
<!-- -->
<!-- adsrv?bG9uZ3NsZWVw -->
<!--<script type="text/javascript" src="/js/dotastic.custom.js"></script>-->
<!-- OH -->
```



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Leveraging Client-initiated Beaconing

- Hosts behind **NATs** or **proxy** servers have a concealed IP address
- Makes it difficult for attackers to know which bot is phoning home
- Beacon identifies host with **an unique identifier**
 - Such as an encoded string with basic information about the host



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Understanding Surrounding Code

- Malware beacon

```
GET /1011961917758115116101584810210210256565356 HTTP/1.1
Accept: * / *
User-Agent: Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1)
Host: www.badsite.com
Connection: Keep-Alive
Cache-Control: no-cache
```

- The standard User-Agent using IE

```
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1;
.NET CLR 2.0.50727; .NET CLR 3.0.04506.648)
```





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Understanding Surrounding Code

- Running the malware a couple more times.

- URIs

```
/1011961917758115116101584810210210256565356 (actual traffic)
/14586205865810997108584848485355525551
/7911554172581099710858484848535654100102
/2332511561845810997108584848485357985255
```

- **Static analysis** can be used to figure out exactly how the request is being created.



Finding the Networking Code

Table 15-5. Windows Networking APIs

WinSock API	WinINet API	COM interface
WSAStartup	InternetOpen	URLDownloadToFile
getaddrinfo	InternetConnect	CoInitialize
socket	InternetOpenURL	CoCreateInstance
connect	InternetReadFile	Navigate
send	InternetWriteFile	
recv	HTTPOpenRequest	
WSAGetLastError	HTTPQueryInfo	
	HTTPSendRequest	

- The HTTPOpenRequest parameter is the **URI** path
- The **URI** are generated
- from calls to GetTickCount, Random, and gethostbyname.



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Sources of Network Content

- The hard-coded data from the malware are most valuable for signature generation
 - Require knowledge of the origin of each piece of network content



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Sources of Network Content

- Random data
- Data from networking libraries
 - Such as the GET created from a call to HTTPSendRequest
- Hard-coded data
- Data about the host and its configuration
 - Hostname, current time, CPU speed
- Data received from other sources
 - Remote server, file system, keystrokes





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Hard-Coded vs. Ephemeral Data

- Malware using lower-level networking APIs such as Winsock
 - Requires more manually-generated content to **mimic** common traffic
 - More hard-coded data
 - Likely the author makes a **mistake** that leaves a signature in the network traffic
 - May misspell a word like **Mozilla**(Mozila, MoZilla)



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How URI is Generated

```
/1011961917758115116101584810210210256565356 (actual traffic)
/14586205865810997108584848485355525551
/7911554172581099710858484848535654100102
/2332511561845810997108584848485357985255
```

```
<4 random bytes>:<first three bytes of hostname>:<time from
GetTickCount as a hexadecimal number>
```

Convert bytes to its ASCII decimal form (for example, the character *a* becomes 97).

Develop an effective **regular expression** for the URI.





Identifying and Leveraging the Encoding Steps

Table 15-6. Regular Expression Decomposition from Source Content

<4 random bytes>		:	<first 3 bytes of hostname>		:	<time from GetTickCount>	
0x91, 0x56, 0xCD, 0x56		:	"m", "a", "l"		:	00057473	
0x91, 0x56, 0xCD, 0x56	0x3A		0x6D, 0x61, 0x6C	0x3A		0x30, 0x30, 0x30, 0x35, 0x37, 0x34, 0x37, 0x33	
1458620586	58		10997108	58		4848485355525551	
((([1-9] 1[0-9] 2[0-5])){0,1}[0-9]){4}	58		[0-9]{6,9}	58		(4[89] 5[0-7] 9[789] 10[012])){8}	





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Creating a Signature

- **Avoid excessive complexity**
 - Slows down the IDS
- Include enough detail to **eliminate false positives**

```
alert tcp $HOME_NET any -> $EXTERNAL_NET $HTTP_PORTS (msg:"TROJAN Malicious Beacon ";  
content:"User-Agent: Mozilla/4.0 (compatible\; MSIE 7.0\; Windows NT 5.1)";  
content:"Accept: * / *"; uricontent:"58"; content:!"|0d0a|referer:"; nocase;  
pcr:"/GET \/>([12]{0,1}[0-9]{1,2}){4}58[0-9]{6,9}58(4[89]|5[0-7]|9[789]|10[012]){8}  
HTTP/";  
classtype:trojan-activity; sid:2000002; rev:1;)
```





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Analyzing the Parsing Routines

- The communication in two directions
 - The traffic that the malware generates
 - The traffic that the malware receives
- Malware strings and the Web page comments both include the common string **adsrv?**

```
<!-- adsrv?bG9uZ3NsZWVw -->
```





- Deep analysis to find potential additional elements
- Parser looks for 3 elements
- `<!—`
- `text`
- `-->`

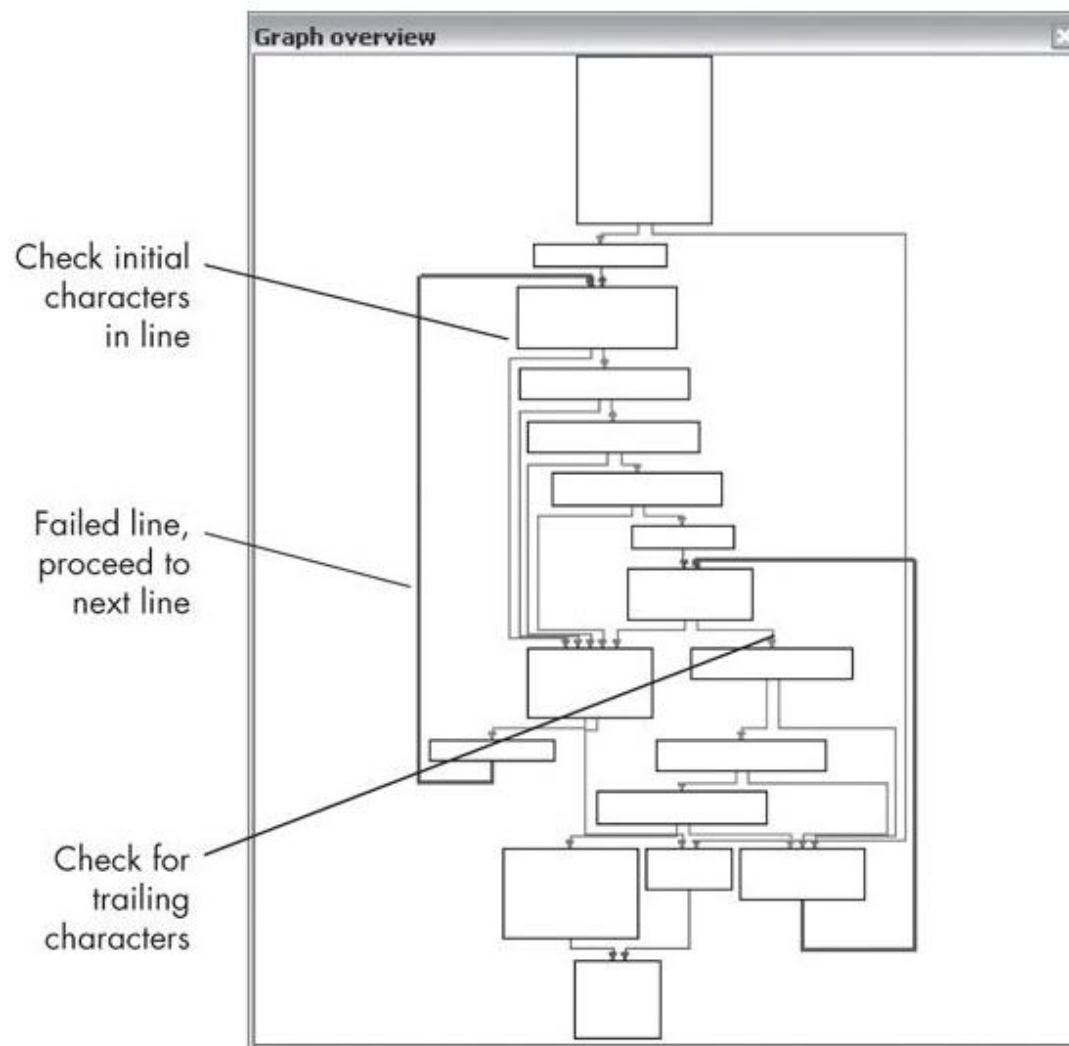


Figure 15-3. An IDA Pro graph of a sample parsing function



Table 15-7. Sample Malware Commands

Command example	Base64 translation	Operation
longsleep	bG9uZ3NsZWVw	Sleep for 1 hour
superlongsleep	c3VwZXJsb25nc2xlZXA=	Sleep for 24 hours
shortsleep	c2hvcnRzbGVlcA==	Sleep for 1 minute
run:www.example.com/fast.exe	cnVuOnd3dy5leGFtcGxlLmNvbS9mYXN0LmV4ZQ==	Download and execute a binary on the local system
connect:www.example.com:80	Y29ubmVjdDp3d3cuZXhhbXBsZS5jb2060DA=	Use a custom protocol to establish a reverse shell





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Possible Signatures

- The five possible commands
- These will work, but any change in the malware will **evade** them

```
<!-- adsrv?bG9uZ3NsZWVw -->  
<!-- adsrv?c3VwZXJsb25nc2x1ZXA= -->  
<!-- adsrv?c2hvcnRzbGVlcA== -->  
<!-- adsrv?cnVu  
<!-- adsrv?Y29ubmVj
```





Targeting Multiple Elements

- These are more general
- The first one accepts any Base64 in a comment with the adsrv prefix

```
pcr:"/<!-- adsrv\[?([a-zA-Z0-9+\\/=]{4})+ -->/"
content:"<!-- "; content:"bG9uZ3NsZWVw -->"; within:100;
content:"<!-- "; content:"c3VwZXJsb25nc2xlZXA= -->"; within:100;
content:"<!-- "; content:"c2hvcnRzbGVlcA== -->"; within:100;
content:"<!-- "; content:"cnVu";within:100;content: "-->"; within:100;
content:"<!-- "; content:"Y29ubmVj"; within:100; content:"-->"; within:100;
```





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Making General Signatures

Target 1: User-Agent string, Accept string, no referrer
Target 2: Specific URI, no referrer





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Understanding the Attacker's Perspective



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Rules of Thumb

- 高质量的特征：从攻击者角度，绕过比较困难
- Focus on elements of the protocol that are part of both end points
 - Look for elements that use code on both the client and server
 - It will be hard for the attacker to change them both





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Rules of Thumb

- Focus on elements of the protocol known to be part of a **key**
 - Such as a User-Agent that identifies bot traffic
 - Again, it would require **updating both ends to change**
- Identify elements of the protocol that are not immediately apparent in traffic
 - This will be less likely to be used by other, sloppy, defenders who leak info to the attacker



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本章知识点

- 网络应对措施（Network Countermeasures）
- 网络事件调查（Safely Investigate an Attacker Online）
- 基于内容的防治（Content-Based Network Countermeasures）
- 动静结合分析（Combining Dynamic and Static Analysis Techniques）
- 攻击者角度分析（Understanding the Attacker's Perspective）



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恶意代码分析与防治技术

第14章：恶意代码网络行为分析

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