

# OPERATION AURORA

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Cyber Espionage is a critical issue. Over 80% of intellectual property is stored online digitally. The computing infrastructure in a typical Enterprise is more vulnerable to attack than ever before. Current security solutions are proving ineffective at stopping cyber espionage. Malware is the single greatest problem in computer security today. Yet, malware represents only the tip of the spear. The true threat is the human being who is operating the malware. This human and the organization represented is the true threat that is targeting information for the purposes of financial gain, theft of state secrets, and theft of intellectual property. True threat intelligence requires reaching beyond malware infections to identify the individuals, country of origin, and intent of the attacker.

## THREAT SUMMARY

The Aurora malware operation was identified recently and made public by Google and McAfee. This malware operation has been associated with intellectual property theft including source code and technical diagrams (CAD, oil exploration bid-data, etc). Companies hit have been publically speculated, including Google, Adobe, Yahoo, Symantec, Juniper Networks, Rackspace, Northrop Grumman, and Dow Chemical. The malware package used with Aurora is mature and been in development since at least 2006.

The Aurora operation is characterized by a remotely operated backdoor program that persists on a Windows computer. This backdoor program has several capabilities that are outlined below.

### KEY FINDINGS

Evidence collected around the malware operation suggest that Operation Aurora is simply an example of highly effective malware penetration. There is not significant evidence to attribute the operation directly to the Chinese Government. However, key actors have been identified in association with malware operations that utilize Chinese systems and native language malware. This has lead to a great deal of speculation about Chinese-State involvement. It must be noted that a large and thriving underground economy exists to both build and disseminate malware worldwide, and that most of this malware is capable of intellectual property theft. The malicious hacking underculture is strong in China, as in Eastern Europe and elsewhere, and clearly enmeshed into a global criminal economy of data theft. While difficult to conclude that these activities receive any form of state sponsorship or direction, the malware operation remains a funded and significant risk to intellectual property in the enterprise.

ASPECT	DESCRIPTION
Target	The operation is targeting intellectual property with no specific industry focus. This is an example of “not knowing what they are looking for until they find it”.
Origin	It is highly probable that the malware was developed in native Chinese language, and the operation control system is designed for Chinese users, indicating the entire operation is Chinese. This does not, however, mean the Chinese Government is using the system.
Developers	Forensic tool-marks in the CRC algorithm can be traced to Chinese origin. That, combined with domain registration information, leads to at least one potential actor, Peng Yong <sup>ii</sup> . The malware has been in development since at least 2006. It has been updated several times.

ASPECT	DESCRIPTION
Operators	Operators of the malware appear to use certain domains for C&C control. Dynamic DNS is a key feature of the operation, with many known C&C servers operating from domains registered through Peng Yong’s 3322.org service.
Intent	The primary intent is the theft of intellectual property.
Coms	Communication is encrypted over HTTP, port 443, obfuscated with a weak encryption scheme. The C&C servers tend to operate from domains hosted on dynamic DNS.

### ATTRIBUTION

At this time, there is very little available in terms of attribution. A CRC algorithm tends to indicate the malware package is of Chinese origin, and many attacks are sourced out of a service called 3322.org — a small company operating out of Changzhou. The owner is Peng Yong, a Mandarin speaker who may have some programming background with such algorithms. His dynamic DNS service hosts over 1 million domain names. Over the last year, HBGary has analyzed thousands of distinct malware samples that communicate with 3322.org. While Peng Yong is clearly tolerant of cyber crime operating through his domain services, this does not indicate he has any direct involvement with Aurora.

TOOLMARK	DESCRIPTION
Embedded Resource Language Code	United States
CRC Algorithm Table of Constants	Embedded systems/ Chinese publication <sup>iii</sup>
DNS registration services	Peng Yong, others



public availability of the Metasploit module “ie\_aurora.rb”. The exploit code used by the original attackers was quickly improved and added to Metasploit thus greatly expanding the potential number of attackers and reliability of code.

The JavaScript performs a heap spray attack and injects the embedded shellcode described below. The JavaScript exploits the vulnerability in Internet Explorer by copying, releasing, and then referencing a Document Object Model (DOM) element.

JAVASCRIPT ARTIFACTS	PATTERN
Initial encrypted dropper download. Deleted file.	C:\%appdata%\a.exe
Decrypted dropper. Deleted file.	C:\%appdata%\b.exe
JavaScript present in Internet Explorer memory space.	<code listed above>
Download URL present in internet history during memory analysis.	http://demo1.ftppaccess.cc/demo/ad.jpg
Other domains associated with Aurora.	sl1.homelinux.org 360.homeunix.com ftp2.homeunix.com update.ourhobby.com blog1.servebeer.com

The shellcode exists as a Unicode escaped variable (sc) in the malicious JavaScript listed below. Upon successful exploitation of Internet Explorer, the shellcode will download an obfuscated second stage executable from <http://demo1.ftppaccess.cc/demo/ad.jpg> which is the dropper. **Note: these files are specific to the sample we analyzed at HBGary, Inc.** The attackers must use a second stage download mechanism to achieve full system access due to memory constraints. It is unlikely that the final payload could be delivered through the original exploit given these conditions. The dropper is XOR encrypted with a 0x95 key. The shellcode copies this encrypted binary to the user’s AppData directory as “a.exe”. The shellcode then decrypts “a.exe” and moves it to “b.exe” in the same directory. Then “b.exe” is executed. The following actionable intelligence can be used to identify exploit remnants in the heap space of Internet Explorer post exploitation attempt. These patterns can be searched for when doing memory analysis of a victim system.

SHELLCODE ARTIFACTS	PATTERN
Self-decrypting code using a constant XOR value.	80 34 0B D8 80 34 0B D8
Kernel32.dll searching code.	64 A1 30 00 00 00 8B 40 0C 8B 70 1C
Push Urlmon string to stack using two push statements.	68 6F 6E 00 00 68 75 72 6C 6D

The following SNORT rules have been released by the Emerging Threats project to detected the final payload command and control communications.

Network Detection Signatures
<pre> alert tcp \$HOME_NET any -&gt; \$EXTERNAL_NET 443 (msg:"ET TROJAN Aurora Backdoor (C&amp;C) client connection to CnC"; flow:established,to_server; content:" ff ff ff ff ff ff 00 00 fe ff ff ff ff ff ff ff ff 88 ff "; depth:20; flowbits:set,ET.aurora.init; classtype:trojan-activity; reference:url,www.trustedsource.org/blog/373/An-Insight-into-the-Aurora-Communication-Protocol; reference:url,doc.emergingthreats.net/2010695; reference:url,www.emergingthreats.net/cgi-bin/cvsweb.cgi/sigs/VIRUS/TROJAN_Aurora; sid:2010695; rev:2;)                     </pre>
<pre> alert tcp \$EXTERNAL_NET 443 -&gt; \$HOME_NET any (msg:"ET TROJAN Aurora Backdoor (C&amp;C) connection CnC response"; flowbits:isset,ET.aurora.init; flow:established,from_server; content:" cc cc cc cc cd cc cc cd cc cc cc cc cc cc "; depth:16; classtype:trojan-activity; reference:url,www.trustedsource.org/blog/373/An-Insight-into-the-Aurora-Communication-Protocol; reference:url,doc.emergingthreats.net/2010696; reference:url,www.emergingthreats.net/cgi-bin/cvsweb.cgi/sigs/VIRUS/TROJAN_Aurora; sid:2010696; rev:2;)                     </pre>

**DROPPER**

The initial dropper is merely a detonation package that decompresses an embedded DLL into the Windows **system32** directory and loads it as a service. The initial dropper is likely to be packed (UPX, etc). The dropper has an embedded DLL that is decompressed to the windows system32 directory. This DLL will be named to resemble existing services (**rasmon.dll**, etc). In order to evade forensics, the file-time of the dropped DLL will be modified to match that of an existing system DLL (**user32.dll**, etc). The dropped DLL is loaded into its own **svchost.exe** process. Several registry keys are created and then deleted as part of this process. Finally, the dropper deletes itself from the system by using a dissolving batch file (**DFS.BAT**, etc).

ACTIONABLE INTELLIGENCE	PATTERN
Service Key & Value Note: deleted after drop	SOFTWARE\Microsoft\Windows NT\CurrentVersion\SvcHost\ <b>Value:</b> SysIns <b>Data:</b> Ups??? (??? are three random chars)
Path to backdoor Note: deleted after stage 1	SYSTEM\CurrentControlSet\Services\Ups???\Parameters\ <b>Value:</b> ServiceDLL <b>Data:</b> (full path to the backdoor)
Path to backdoor Note: persistent	SYSTEM\CurrentControlSet\Services\RaS???\Parameters\ <b>Value:</b> ServiceDLL <b>Data:</b> (full path to the backdoor)

ACTIONABLE INTELLIGENCE	PATTERN
Potential variation	SYSTEM\CurrentControlSet\Services\ RaS???\Parameters\ <b>Value:</b> ServiceDLL <b>Data:</b> %temp%\c_####.nls (where #### is a number)
Potential variation	SYSTEM\CurrentControlSet\Services\ RaS???\Parameters\ <b>Value:</b> ServiceDLL <b>Data:</b> %temp%\c_1758.nls

### PAYLOAD

The payload uses two-stage installation. During stage one, the dropper will install the payload as a service running under the name Ups???. (where ??? are three random characters). Once executing, the payload will immediately delete the first service and enter stage-two. During stage-two, the payload will register a new, second service under the name RaS???. (where ??? are three random characters). This new service will point to the same backdoor DLL, no new files are involved. **Note: the three character prefixes Ups and RaS can easily be modified by the attacker.**

Once the new service is registered, the payload will access an embedded resource that is encrypted. The decryption goes through several phases. The encrypted data block contains the DNS name for the command and control server (homeunix.com, etc). **This data block is configurable before the malware is deployed.** The data block length is hard-coded (0x150 or 336 bytes). During phase one, this data block is fed through a simple XOR (0x99), resulting in an ASCII-string. Next, the resulting ASCII-string is fed into a base64 decoding function, producing a binary string. Finally, the resulting base64 decoded binary string is fed through another XOR (0xAB), resulting in clear-text. The three primary encryption loops are colored and marked in **Figure 1**. The resulting clear-text buffer contains several fields in both ASCII and UNICODE, including the C&C server address.

#### GLANCE UNDER THE HOOD

##### buffer after phase one XOR:

```
mJ2bhcPExs7exclThcjExqurnauYq
```

##### buffer after base64 decoding:

```
ÄÄÆÏpÄÄÖ...ÈÄÆ«« «~«Y««†«š«š«Z«š«œ
```

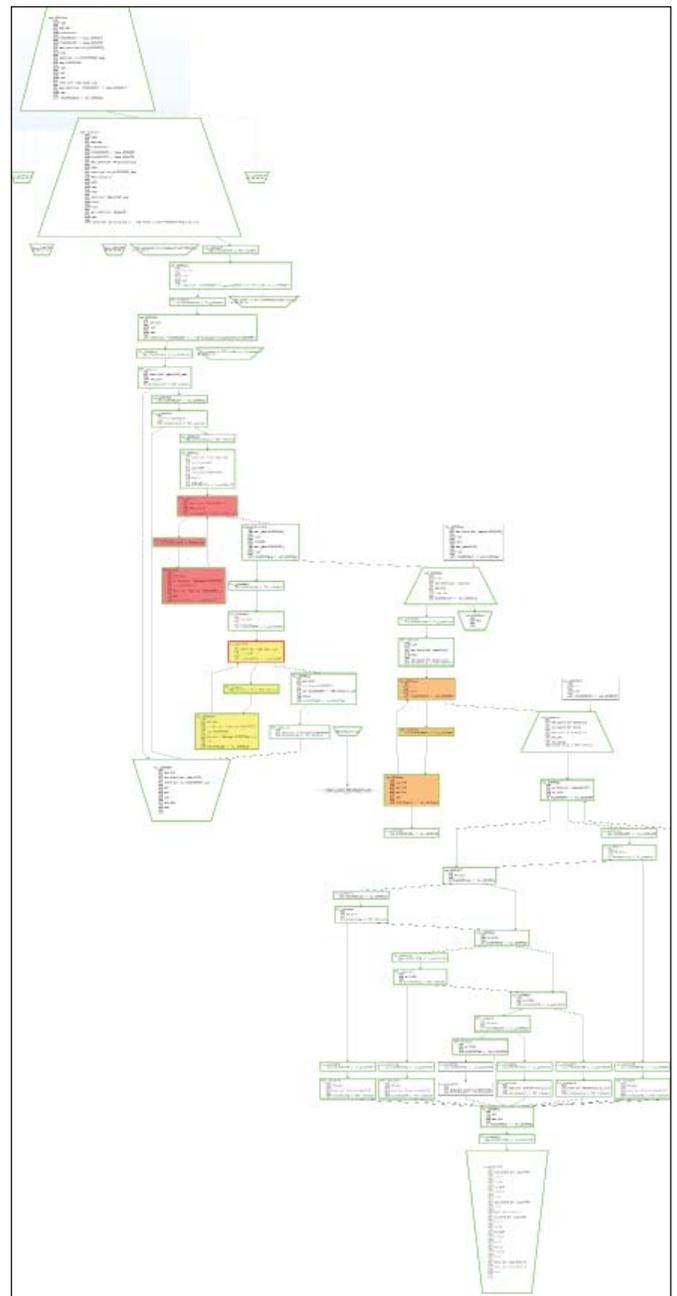


Figure 1. Base64 and XOR Encryption Scheme

ACTIONABLE INTELLIGENCE	PATTERN
C&C Server DNS	* .homeunix.com (where * is any subdomain) * .homelinux.com * .ourhobby.com * .3222.org * .2288.org * .8866.org * .ath.cx * .33iqst.com * .dyn dns.org * .linode.com * .ftppaccess.cc * .filoups.info * .blogsite.org

The payload will create additional registry keys.

ACTIONABLE INTELLIGENCE	PATTERN
Additional Key	HKLM\Software\Sun\1.1.2\IsoTp
Additional Key	HKLM\Software\Sun\1.1.2\AppleTlk

Other potential dropped files, as reported by McAfee:

ACTIONABLE INTELLIGENCE	PATTERN
Additional File	securmon.dll
Additional File	AppMgmt.dll
Additional File	A0029670.dll (A00#####.dll)
Additional File	msconfig32.sys
Additional File	VedioDriver.dll
Additional File	acelpvc.dll
Additional File	wuauclt.exe
Additional File	jucheck.exe
Additional File	AdobeUpdateManager.exe
Additional File	zf32.dll

### COMMAND AND CONTROL

The payload communicates with its command and control server over port 443. The source port is randomly selected. While outbound traffic appears to be HTTPS, the actual traffic uses a weak custom encryption scheme. The command and control packets have a very specific format.<sup>iv</sup>

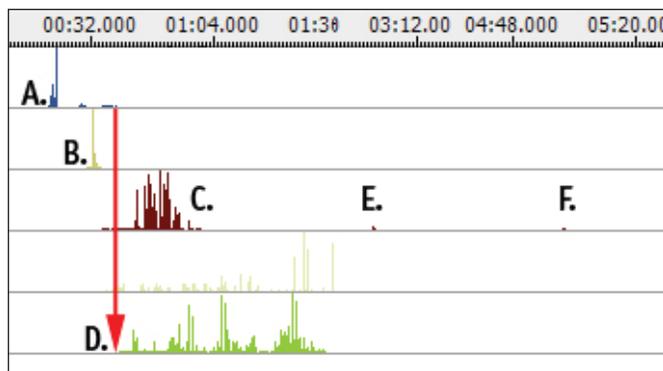
command	parms	0x00000001	payload len	CRC	KEY	payload
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The payload section is encrypted with a key selected by using GetTickCount. This means each infected node has its own key. The key is embedded in the header of the packet, and is easily recovered.

## DIAGNOSE

### HOW THE MALWARE WORKS

The primary control logic can be found in the module registered under the service key (rasmon.dll, etc.). This module has been written in c and includes several specific methods and encodings that provide forensic track-ability.



The above screenshot illustrates a REcon™ trace on the malware dropper and subsequent service creation. Location A. represents the dropper program, which unpacks itself and decompresses a file to the system32 directory. Point B. represents the initial svchost.exe startup, which is loading the malware payload. Location C. is the actual execution of the malware service, which remains persistent. At points E. and F. you can see the malware checking in with the command and control server. Finally, location D. represents the dissolvable batch file which deletes the initial dropper and then itself.

### CAPABILITY

The malware has generic and flexible capabilities. There are distinct command handlers in the malware that allow files to be stolen and remote commands to be executed. The command handler is illustrated in Figure 2. At location A. the command number is checked. At locations marked B. are each individual command handler, as controlled by the C&C server and command

number in the C&C packet. Location C. is where the result of each command is sent back to the C&C server.

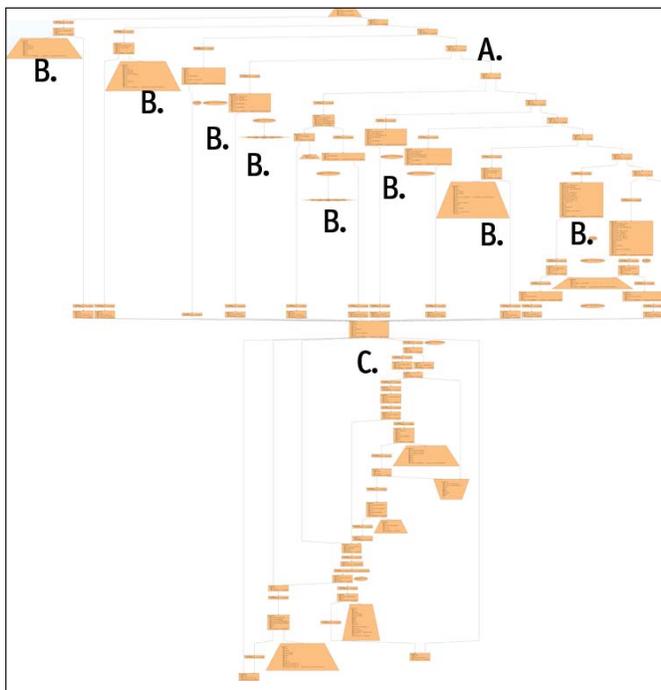


Figure 2. C&C Command Parser

### COPYCATS AND VARIANTS

With the release of MS10-002, and the subsequent integration with Metasploit, the exploit vector used with Aurora has been adopted laterally within the malware development economy. Therefore, the use of MS10-002 should not be construed as an Aurora infection without further analysis of the dropped payload. Forensic toolmarks and link analysis have revealed several different threat groups who are employing common IE exploit vectors. HBGary is currently tracking several groups who operate malware systems of this nature.

HBGary is using forensic toolmarks to trace the source code origins of binary malware samples dropped in conjunction with the MS10-002 exploit vector. For example, in Figure 3, link analysis is being used to track the identity of a threat actor in conjunction with his known Digital DNA™. HBGary's Digital DNA™ database not only codifies the behavior of software, but also the coding idioms, algorithms, and methods of individual developers. In this way, individual threat actors can be tracked with Digital DNA™.

In the example, link analysis is provided by Palantir™. The screenshot illustrates only a subset of the data being tracked by HBGary, and sensitive information has been redacted.

At location 1. is a dropper obtained from an exploit server directly accessed from the extracted shellcode from a MS10-002 JavaScript vector. Location 2. represents a forensic toolmark within the dropped executable. This toolmark was obtained using physical memory assessment of the live executable, after it was allowed to unpack itself in a virtual machine. This assessment was performed with HBGary Responder™. At location 3., the recovered toolmark(s) were researched against published source code artifacts on the Internet. From this, a single posting was discovered with this exact toolmark, and this posting exists only in one place and is of Chinese origin. From this, the author of the source code was determined to be XXXXXXXX. At location 4., all social cyberspaces used by XXXXXXXX were then enumerated. From this, postings in Traditional and Simplified Chinese were discovered that confirm that XXXXXXXX is the author and supplier of a malware package known as 'NB' or 'Netbot Attacker'. Within the social space around 'Netbot Attacker' are individuals who are testing and/or asking for technical support regarding the malware package operation. These individuals have been grouped within Palantir™ as 'technical support for bot' at location 5.

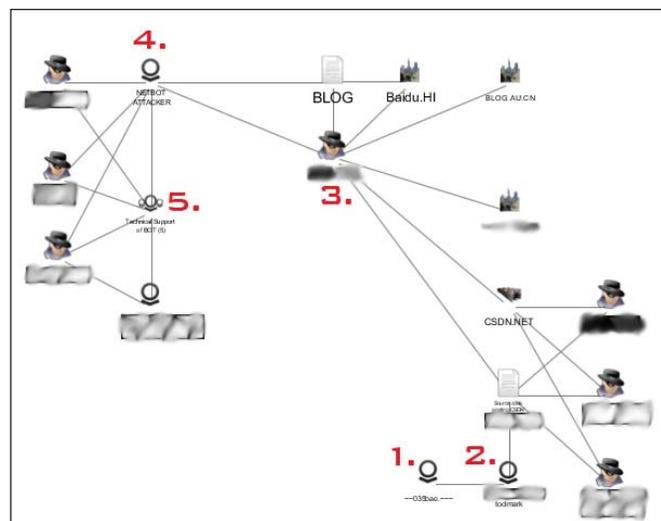


Figure 3. Link Analysis of Malware Actors using Palantir™

The above process, when carried further, produces many more social links. Attribution such as this allows resolution and visibility into the intent of individual threat groups.

## RESPOND

Several Enterprise products have the capability to scan for and potentially remove the Aurora malware. Detection of the malware is covered in detail, from multiple aspects, in the Detect section above. When using a Digital DNA™ capable platform such as McAfee ePO, you can search the Enterprise for the following Digital DNA sequence (recommend a tight match, 90% or higher).

DIGITAL DNA SEQUENCE FOR AURORA MALWARE
01 B4 EE 00 AE DA 00 8C 16 00 89 22 00 46 73 00 C6 49 00 0B AE 01 E7 9F 04 05 81 01 0E DF 01 79 D8 00 25 6A 00 15 49 00 47 22 00 4B 67 0F 2D CC 01 29 67 01 35 99

To thwart command and control and prevent data loss, known C&C domains should be blocked at the egress firewall. The domains listed in the Detect section represent a significant set of those currently known to be operating. IDS signatures similar to the one illustrated in the Detect section should be used to detect inbound exploit attempts, and machines accepting this data should be scanned for potential infections. Many A/V products now contain signatures for the Aurora exploit and will be effective in detection and removal. However, the attackers that represent the threat will not be deterred, and variants of the attack are nearly assured.

FACTORS	DESCRIPTION
C&C protocol	If a variant is developed, it will very likely use the same C&C protocol, but may change the header of the packet and the constants used for connection setup. This will evade IDS / Firewall rules designed to detect the current scheme. It is unlikely the attackers will change the encryption setup, however.
Installation and Deployment	The method used to install the service is highly effective. Although the filenames will likely change, the actual method will likely remain.

## INOCULATION

### DIGITAL DNA INOCULATION SHOT

HBGary has prepared an **inoculation shot** for this malware. The inoculation shot is a small, signed binary that will allow you to scan for, and optionally remove, this malware from your Enterprise network. The aurora innoculation shot can be downloaded from [www.hbgary.com](http://www.hbgary.com).

When the aurora innoculation shot is executed it will query the user for authentication credentials. Optionally the user can just hit “cancel” to use the currently logged on USER’s authentication token. Some sample usages are listed below.

#### To scan a single machine:

AuroraInnoculation.exe -scan 192.168.0.1  
AuroraInnoculation.exe -scan MYBOXNAME

#### To scan multiple machines:

AuroraInnoculation.exe -range 192.168.0.1 192.168.0.254

#### To automatically attempt a clean operation:

AuroraInnoculation.exe -range 192.168.0.1 192.168.0.254 -clean

#### To scan a list of machines in a .txt file:

AuroraInnoculation.exe -list targets.txt

## MCAFFEE EPO CUSTOMERS

### DETECTION OF AURORA THREATS WITH DIGITAL DNA FOR EPO

Customers of McAfee ePolicy Orchastrator, integrated with Digital DNA, can detect emerging advanced persistent threats. To detect Aurora, users should perform a Digital DNA Sequence search with the above mentioned sequence for Aurora, and set a fuzzy match of 90% or greater. Once machines are detected, the user is encouraged to use the freely available **inoculation shot** to remove the infection.

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## MORE INFORMATION

### ABOUT HBGARY, INC

HBGary, Inc is the leading provider of solutions to detect, diagnose and respond to advance malware threats in a thorough and forensically sound manner. We provide the active intelligence that is critical to understanding the intent of the threat, the traits associated with the malware and information that will help make your existing investment in your security infrastructure more valuable.

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## REFERENCES

- i <http://siblog.mcafee.com/cto/operation-%E2%80%99Aurora%E2%80%9D-hit-google-others/>
- ii <http://www.thetechherald.com/article.php/201004/5151/Was-Operation-Aurora-nothing-more-than-a-conventional-attack>
- iii <http://www.fjbmccu.com/chengxu/crcsuan.htm>  
(via: <http://www.secureworks.com/research/blog/index.php/2010/01/20/operation-aurora-clues-in-the-code/>)
- iv <http://www.avertlabs.com/research/blog/index.php/2010/01/18/insight-into-the-aurora-communication-protocol/>
- v <http://www.symantec.com/connect/blogs/trojanhydraq-incident-analysis-aurora-0-day-exploit>



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