



Interested in learning
more about security?

SANS Institute InfoSec Reading Room

This paper is from the SANS Institute Reading Room site. Reposting is not permitted without express written permission.

Code Red and Code Red II: Double Dragons

This paper describes the mechanisms of the Code Red and Code Red II worms and the software vulnerabilities that went unpatched allowing the worms to propagate.

Copyright SANS Institute
Author Retains Full Rights

AD

Build your business'
breach action plan.

START NOW

 **LifeLock**
BUSINESS SOLUTIONS

No one can prevent all identity theft. © 2016
LifeLock, Inc. All rights reserved. LifeLock
and the LockMan logo are registered
trademarks of LifeLock, Inc.

Code Red and Code Red II: Double dragons

SANS GSEC Practical Assignment Version 1.2f

Kittipong Teeraruangchaisri

September 15, 2001

Before July 2001, if you ask people about Code Red, you may hear they say about pop rock artist from England whose songs had been in the music charts years ago. However, in July 2001 people recognize the name “Code Red” as one of the harmful worm that spread through the Internet.

This year, many worms have been discovered on various platforms. In January, Ramen worm is the one that use vulnerability of wu-ftp software on Linux platform to spread. Another one called Lion worm, which exploits vulnerability of BIND DNS server on Unix system, has been discovered in March. The sadmind/IIS worm attack both Sun Solaris and Windows platform by using exploitation on Solaris to propagate and then attack Microsoft IIS web server.

On 16 July, 2001 eEye digital security found the worm that use IIS Index Server ISAPI Extension vulnerability, also known as “.ida vulnerability”, to propagate. This is the one called “Code Red” worm.

This worm has become more familiar when NIPC(National Infrastructure Protection Center) issued an alert regarding the threat from worm propagation on July 29.

At first sight

In my opinion, Windows platform is likely to be the better place for worm to stay and propagate compare to Unix system because Windows always use by less skill users (i.e. home users) who have less sense of security. In addition, there is large number of machines running Windows all around the world and default installation of Windows system contains many serious vulnerabilities.

When I first saw the news about Code Red worm in security mailing list, I didn't think it would be a serious threat because it exploits .ida vulnerability, which had been found months ago, all of machines under my administration had been patched. Also, this vulnerability is on Window NT and 2000 that open web server service, so it should not affect home users who use Windows 98 and Windows ME. However, when I read more information about this worm, I could realize that I should prepare to deal with its effect.

The Vulnerability

Vulnerability used by this worm was also discovered by eEye digital security on June 18. Microsoft issued security bulletin MS01-033 to state this vulnerability. It is caused by unchecked buffer in idq.dll, which is part of Microsoft Indexing Service. The attacker can use buffer overflow technique to run code in the context of local SYSTEM account on target machine.

This is a serious vulnerability. The attacker can compromised target machine by insert malicious code to HTTP request and send them to an affected machine. The similar vulnerability, IIS Unicode vulnerability (MS00-078), had been discovered months ago and it had been used to create sadmind/IIS worm, which I have mentioned earlier in

- Even though it can spread very fast, the recovery process is so simple. There is no files or backdoor leave on the infected system. Thus, you can recover from the worm by installing patch to make sure that the system will not be infected again then reboot the machine to clear the worm out of the system.
- The system administrator, whose system has limited network bandwidth, will be automatically alerted on the infection of the worm by the worm itself because network bandwidth will be depleted that will cause problem to other network application.

On August 6, while Code Red were spreading all around the world, CERT issued incident note stated that there were another worm call Code Red II which used the same .ida vulnerability spreading through out the Internet.

Code Red II: The real threat

Actually, Code Red II is another worm that does not seems to be mutated from original version of Code Red. The only similar activity is that both of them will heavily scan other machines on Internet to propagate. All other activities of Code Red II are different from original Code Red.

Code Red II: Attacking function

Code Red II itself does not have any attacking function like Code Red. Instead of that it install additional backdoor to allow attacker to use the infected machine as one of the troop to make further attack. It will copy the cmd.exe, which is command shell, to be root.exe in default executable IIS virtual directory (i.e. /scripts and /msadc). This will allow anyone to remotely run programs or commands on the infected machines that could allow further compromise of the system.

In addition, Code Red II will make it self more tolerant by installing trojan version of explorer.exe on c:\ for it will be run every time users log on to system. Its version of explorer.exe is designed to open more backdoor on the system. It will modify following system registries:

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W3SVC\Parameters\Virtual Roots\Scripts
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W3SVC\Parameters\Virtual Roots\msadc
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W3SVC\Parameters\Virtual Roots\c
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W3SVC\Parameters\Virtual Roots\d
HKEY_LOCAL_MACHINE\Software\Microsoft\Windows
NT\CurrentVersion\Winlogon\SFCDisable
```

The first two registries will be modify to allow program execution in IIS virtual directory /scripts and /msadc. Other two entries are added to create new virtual directory /c and /d that will be link to physical path c:\ and d:\ and also allow program execution on both of them. These registries modification is designed to make sure that attacker can be always access cmd.exe in the system partition in addition to Trojan root.exe, which have copied to executable virtual directory. The last one is modified to disable file system checker feature of Windows 2000.

The file explorer.exe make worm hard to kill. As long as worm explorer process is running, virtual directories that used as backdoor are always active. Restart the infected machine cannot stop explorer.exe from running because it will be started automatically when user log on.

Code Red II: Propagating function

Code Red II scanning function is much different from original Code Red in many ways.

1. Number of threads used: While original Code Red will create not more than 100 threads to scan others and propagate, Code Red II use at least 300 threads (up to 600 threads) to do the scanning. Obviously, Code Red II will use much more network resources than original Code Red.
2. Scanning pattern: Original Code Red use random algorithm to select target that makes its target more scattered through out the Internet but Code Red II use the different algorithm.

Code Red II will select its target IP address based on local IP address of the infected machines. Most of which will have the same first and second octet as infected host. Only small number of target IP are random and not related to IP of infected machines. That means Code Red II target to machine near its current host first. However, some random target IP are still be use to spread more worm to Internet.

The scanning method of Code Red II makes its behavior much different than original Code Red. Code Red II use more threads than Code Red that make it spread faster. The way it select its next target may lead to more chance of finding vulnerable host, base on the assumption that adjacent IP address is likely to be owned by the same owner and if one machine is vulnerable, other machines are believe to be vulnerable too.

The impact: Traffic Congestion and denial of service

The main impact of these two worms is traffic congestion that is denial of service attack especially on the organization that has limited Internet connection bandwidth. Code Red II makes more severe impact than Code Red.

1. If the worm infects the machines in your own network, outbound traffic will be used to scan other hosts. For the network with low bandwidth (i.e 128 Kbps), only one infected machine can saturate all outbound bandwidth.
2. Other infected machines try to scan your network; inbound traffic will be increased due to the scan.

For original Code Red, because of its random target selection the scanning will be originated from different sources and only small number of scanning from each source. The more number of total infections will lead to higher scanning rate you will receive. Fortunately, public awareness on this issue make number of infection under control before scanning function fully activated in August.

For Code Red II, the scanning traffic might be very high even though total number of infection is low. If the infected hosts use IP address adjacent to your network, you may receive many scanning attempts because Code Red II aim to infect nearby IP address first and it selects its target as a group.

For instance, if you network use IP 10.2.0.0/16 and Code Red II has infected the machine that use IP 10.2.3.4, the infected host will mostly scan IP address that begin with 10.2.x.x so your network will be hit heavily.

3. Many products of Cisco network equipments may stop working when receive some number of traffic. Cisco 600 series DSL router will stop forwarding packet and need a restart after receive Code Red scanning.
4. Dial-up Internet users may suffer from being scanned that will consume most of modem bandwidth.

The impact: Backdoor/Trojan

Code Red II leave backdoor on your system even though it had been cleared. This is another dangerous action of this worm because it can lead to further compromise of the infected system that is very hard to detect and recover.

For instance, one of hacker is familiar with this worm so he know about the backdoor that the worm leave on the system. Then he scans Internet IP to find the backdoor leaved by the worm. After that he may compromise the host and install another trojan to the infected machine. The trojan might be the one that widely used or the brand new one which is very hard to detect. Now even though machine owner clean the Code Red II and close the backdoor, the hacker are still able to access to the compromised system.

Defensive Action

The protection can be done at both perimeter/network and system security level.

1. Perimeter/network level

Firewall or router with high-level filtering can filter out the request send by worm. Checkpoint Firewall-1 can stop both Code Red inbound and outbound request by defining rules to block Code Red HTTP request (i.e. HTTP request containing ".ida"):

<http://support.checkpoint.com/public/publisher.asp?id=a0ff902e-7d65-11d5-97ed-080020a7af00&resource=&number=0&isExternal=0>

Cisco has also provided step to configure Cisco router to block Code Red HTTP request:

http://www.cisco.com/warp/public/63/nbar_acl_codered.shtml

For network that never need inbound HTTP traffic, block all inbound traffic on port 80 using basic router access list or firewall rule should be the best solution. For dial-up users, typically they do not need any inbound HTTP request; ISP may block all inbound HTTP traffic at access server to protect them from problems and mitigate the propagation of the worm.

2. System security level

Install patch that fix this vulnerability is the best solution. Remember that you should install all patch before connect the machine to network. When the worm is spreading around, affected machine can be infected immediately after connecting to network.

Microsoft has released the cumulative patch that fixes all IIS vulnerabilities include .ida vulnerability. Details can be found in Microsoft security bulletin MS01-044: <http://www.microsoft.com/technet/security/bulletin/ms01-044.asp>

Worm Detection

Security scanning software can be used to search for vulnerable host in your network. In addition, eEye Digital Security provide free tool to scan range of IP address for .ida vulnerable machines:

<http://www.eeye.com/html/Research/Tools/CodeRedScanner.exe>

Most of intrusion detection system can detect the exploitation of .ida vulnerability that indicates the worm scanning. From www.snort.org, following Snort rule can be used to detect this type of attack:

```
alert tcp $EXTERNAL_NET any -> $HTTP_SERVERS 80 (msg:"WEB-IIS ISAPI
.ida attempt"; uricontent:".ida?"; nocase;
dsize:>239; flags:A+; reference:arachnids,552; classtype:attempted -
admin; reference:cve,CAN-2000-0071; sid:1243
; rev:1;)
```

Worm Cleaning

Original Code Red do not need special step for cleaning. Simply install patch and restart the machine to clear the worm.

For Code Red II, you need to verify that your system had been compromised or not. If you are sure that only Code Red II is infected and no other backdoor/trojan in the system you can use automatic cleaning tools release by many vendors include Microsoft to clean your system.

However, if you suspect that your system has been compromised, you need more action than just cleaning the worm. Recovering from compromised system need many steps include re-install the whole system and restore data from backup. You may consult CERT guideline at the following link:

http://www.cert.org/tech_tips/win-UNIX-system_compromise.html

The light side

Although the worm may cause much damage to computer system, the protection measures against worm sometimes improve security protection system. It raises users awareness of system security. Great number of machines had been patched so they safe from many security issues not only Code Red because cumulative patch from Microsoft will correct all known security issues of IIS include other serious vulnerabilities such as Unicode vulnerability.

References:

CERT. "CERT Advisory CA-2001-11 sadmind-IIS Worm". May 10, 2001.
URL: <http://www.cert.org/advisories/CA-2001-11.html>.

CERT. "Advisory CA-2001-19 "Code Red" Worm Exploiting Buffer Overflow In IIS Indexing Service DLL". August 23, 2001.
URL: <http://www.cert.org/advisories/CA-2001-19.html>.

CERT. "Incident Note IN-2001-09". August 6, 2001.
URL: <http://www.cert.org/advisories/CA-2001-19.html>.

eEye Digital Security. ".ida "Code Red" Worm". July 17, 2001.
URL: <http://www.eeye.com/html/Research/Advisories/AL20010717.html>.

eEye Digital Security. "CodeRedII Worm Analysis". August 4, 2001.
URL: <http://www.eeye.com/html/Research/Advisories/AL20010804.html>.

eEye Digital Security. "CodeRed Scanner from eEye Digital Security".
URL: <http://www.eeye.com/html/Research/Tools/codered.html>.

Microsoft Corp. "Microsoft Security Bulletin MS01-033 Unchecked Buffer in Index Server ISAPI Extension Could Enable Web Server Compromise". June 18, 2001.
URL: <http://www.microsoft.com/technet/security/bulletin/MS01-033.asp>.

Microsoft Corp. "Microsoft Security Bulletin MS01-044 Cumulative Patch for IIS". August 15, 2001.
URL: <http://www.microsoft.com/technet/security/bulletin/MS01-044.asp>.

National Infrastructure Protection Center. "ALERT 01--016 Code Red Worm". July 29, 2001.
URL: <http://www.nipc.gov/warnings/alerts/2001/01-016.htm>.

Symantec Corp. "CodeRed II" Symantec Security Response. September 5, 2001.
URL: <http://www.symantec.com/avcenter/venc/data/codered.ii.html>.

Snort Web site. "Snort Current Rules Official Release". August 13, 2001.
URL: <http://www.snort.org/downloads/snortrules.tar.gz>.

Cisco System Inc. "Cisco Security Advisory: "Code Red" Worm - Customer Impact". August 11, 2001.
URL: <http://www.cisco.com/warp/public/707/cisco-code-red-worm-pub.shtml>.

Cisco System Inc. "Using Network-Based Application Recognition and Access Control Lists for Blocking the "Code Red" Worm at Network Ingress Points".
URL: http://www.cisco.com/warp/public/63/nbar_acl_codered.shtml.

Checkpoint Software Technologies Ltd. "Solution: How to use the VPN-1/FireWall-1 HTTP Security Server to protect against the Code Red worm" Secure Knowledge Database.
URL: <http://support.checkpoint.com/public/publisher.asp?hotid=a0ff902e-7d65-11d5-97ed-080020a7af00>.

Richman, Dan. "State pressing Qwest for refunds after 'Code Red II' DSL breakdowns" MSNBC News. August 22, 2001.

URL: <http://www.msnbc.com/local/pisea/m82670.asp>.

Junnarkar, Sandeep. and Fried, Ian. "Code Red II: A double whammy" ZDNet News. August 6, 2001.

URL: <http://www.zdnet.com/zdnn/stories/news/0,4586,5095260,00.html>.

Ananova Ltd. "Code Red attack to be less damaging than thought". August 17, 2001.

URL: http://www.ananova.com/news/story/sm_376461.html.

© SANS Institute 2001, Author retains full rights.



Upcoming SANS Training

[Click Here for a full list of all Upcoming SANS Events by Location](#)

SANS Paris June 2018	Paris, FR	Jun 25, 2018 - Jun 30, 2018	Live Event
SANS Minneapolis 2018	Minneapolis, MNUS	Jun 25, 2018 - Jun 30, 2018	Live Event
SANS Vancouver 2018	Vancouver, BCCA	Jun 25, 2018 - Jun 30, 2018	Live Event
SANS London July 2018	London, GB	Jul 02, 2018 - Jul 07, 2018	Live Event
SANS Cyber Defence Singapore 2018	Singapore, SG	Jul 09, 2018 - Jul 14, 2018	Live Event
SANS Charlotte 2018	Charlotte, NCUS	Jul 09, 2018 - Jul 14, 2018	Live Event
SANSFIRE 2018	Washington, DCUS	Jul 14, 2018 - Jul 21, 2018	Live Event
SANS Cyber Defence Bangalore 2018	Bangalore, IN	Jul 16, 2018 - Jul 28, 2018	Live Event
SANS Pen Test Berlin 2018	Berlin, DE	Jul 23, 2018 - Jul 28, 2018	Live Event
SANS Riyadh July 2018	Riyadh, SA	Jul 28, 2018 - Aug 02, 2018	Live Event
Security Operations Summit & Training 2018	New Orleans, LAUS	Jul 30, 2018 - Aug 06, 2018	Live Event
SANS Pittsburgh 2018	Pittsburgh, PAUS	Jul 30, 2018 - Aug 04, 2018	Live Event
SANS San Antonio 2018	San Antonio, TXUS	Aug 06, 2018 - Aug 11, 2018	Live Event
SANS August Sydney 2018	Sydney, AU	Aug 06, 2018 - Aug 25, 2018	Live Event
SANS Boston Summer 2018	Boston, MAUS	Aug 06, 2018 - Aug 11, 2018	Live Event
Security Awareness Summit & Training 2018	Charleston, SCUS	Aug 06, 2018 - Aug 15, 2018	Live Event
SANS Hyderabad 2018	Hyderabad, IN	Aug 06, 2018 - Aug 11, 2018	Live Event
SANS New York City Summer 2018	New York City, NYUS	Aug 13, 2018 - Aug 18, 2018	Live Event
SANS Northern Virginia- Alexandria 2018	Alexandria, VAUS	Aug 13, 2018 - Aug 18, 2018	Live Event
SANS Krakow 2018	Krakow, PL	Aug 20, 2018 - Aug 25, 2018	Live Event
SANS Chicago 2018	Chicago, ILUS	Aug 20, 2018 - Aug 25, 2018	Live Event
Data Breach Summit & Training 2018	New York City, NYUS	Aug 20, 2018 - Aug 27, 2018	Live Event
SANS Prague 2018	Prague, CZ	Aug 20, 2018 - Aug 25, 2018	Live Event
SANS Virginia Beach 2018	Virginia Beach, VAUS	Aug 20, 2018 - Aug 31, 2018	Live Event
SANS San Francisco Summer 2018	San Francisco, CAUS	Aug 26, 2018 - Aug 31, 2018	Live Event
SANS Copenhagen August 2018	Copenhagen, DK	Aug 27, 2018 - Sep 01, 2018	Live Event
SANS SEC504 @ Bangalore 2018	Bangalore, IN	Aug 27, 2018 - Sep 01, 2018	Live Event
SANS Wellington 2018	Wellington, NZ	Sep 03, 2018 - Sep 08, 2018	Live Event
SANS Amsterdam September 2018	Amsterdam, NL	Sep 03, 2018 - Sep 08, 2018	Live Event
SANS Tokyo Autumn 2018	Tokyo, JP	Sep 03, 2018 - Sep 15, 2018	Live Event
SANS Tampa-Clearwater 2018	Tampa, FLUS	Sep 04, 2018 - Sep 09, 2018	Live Event
SANS MGT516 Beta One 2018	Arlington, VAUS	Sep 04, 2018 - Sep 08, 2018	Live Event
SANS Cyber Defence Canberra 2018	OnlineAU	Jun 25, 2018 - Jul 07, 2018	Live Event
SANS OnDemand	Books & MP3s OnlyUS	Anytime	Self Paced