HTTP sinkholing in a service provider environment

With a short introduction to PHP malware obfuscation

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Seeweb s.r.l.

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3. The benefits
4. Common PHP obfuscation methods

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Who is Marco

Marco d'Itri

- Involved in Internet things in Italy since the mid '90s (we may have met on Usenet...).
- A Debian Developer for 25 years (mutt, inn, ppp, netbase, hotplug, udev, systemd...).
- I also wrote the `whois` command used by all Linux distributions.
- Employed by Seeweb, an italian cloud infrastructure, hosting and colocation provider.
- Designed and manages the Seeweb network (and other services).
- Designed and manages the Seeweb SOC.

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What is Seeweb?

A cloud services provider in Italy

- 1998: founded as a pure hosting provider, after an experience as an ISP.
- 2005: opens a second data center in the Via Caldera Campus in Milano.
- 2010: first in Italy to provide cloud infrastructure.
- 2015: creates DHH S.p.A., a company listed on the Milano stock exchange which invests in cloud computing companies in the emerging markets of Europe.

Seeweb owns 4 data centers in Frosinone and Milano.

DHH is also present in Switzerland, Slovenia, Croatia, Serbia and Bulgaria.

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What is a sinkhole?

Sinkholing: diverting to your own servers the communications from malware to their command and control (C&C) servers.

The Seeweb sinkhole

- HTTP traffic to specific IP addresses.
- Custom answers for specific DNS queries.

HTTP requests from web malware in the Seeweb network are redirected to our server for logging.
And then we send our own answers.

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What is being sinkholed?

What kind of request are sinkholed?

- Downloading the second stages of malware.
- Exfiltrating credentials or requesting data from a C&C.

How are the addresses collected?

- Reverse engineering malware.
- Analysis of the resolvers' cache dumps.
- Passive DNS (more subdomains of already known domains).
- DNS enumeration.
- Looking at `/server-status` on large servers.

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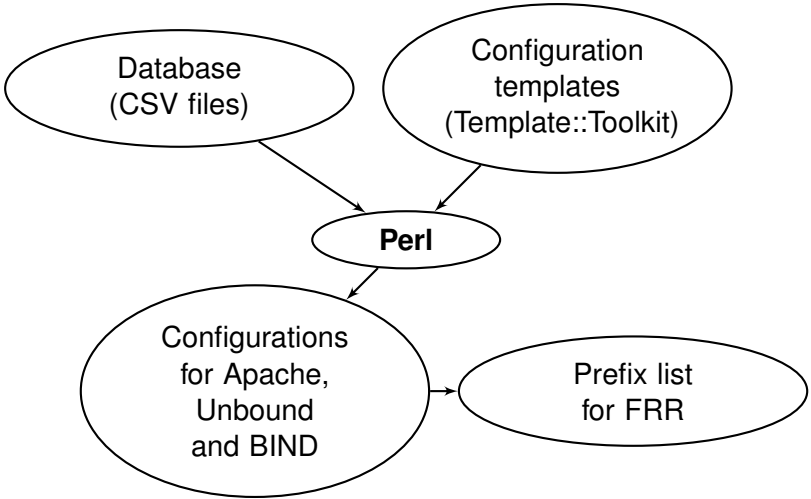
The components



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The database

The database of sinkholed addresses is organized in CSV files.

- IP
- Domain/URL (if known)
- Currently active
- Campaign name
- Type of payload (shell, PHP, Javascript, etc...)
- Expected reply (for validation)
- Notes

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Apache configuration (1)

Answer the malware requests in a creative way:

```
<VirtualHost [% http_bind_list %] >
        ServerName sinkhole.seeweb.it

        ErrorLog /var/log/apache2/sinkhole/error.log
        CustomLog /var/log/apache2/sinkhole/[% log_name.$campaign ||          ↪
        log_name.default %].log sinklog

        DocumentRoot /var/www/sinkhole/
```

...

Each virtual host listens on up to hundreds of IP addresses.

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Apache configuration (2)

```
...
        RewriteCond %{REQUEST_METHOD} =POST
        RewriteRule . /cgi-bin/log-post-data [L,PT]

        RewriteRule \.js$ /logger.js [L]
        RewriteRule \.sh$ /logger [L]

        # probably it will be run in a shell
        RewriteCond %{HTTP_USER_AGENT} ^(curl|Wget)/
        RewriteRule ^/ /logger [L]

        # or else probably it will be executed as php
        RewriteCond %{REQUEST_METHOD} =GET
        RewriteRule . /logger.php [L]
</VirtualHost>
```

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The logger

This is the typical reply sent to the malware:

```php
<?php
$msg  = "PROGRAM: php\n";
$msg .= "CWD: " . getcwd() . "\n";
$msg .= "PID: " . getmypid() . "\n";
$msg .= "USER: " . get_current_user() . "\n";
$msg .= "\n";

foreach ($_SERVER as $var => $value) {
          $msg .= "$var=$value\n";
}

mail("soc+magic@seeweb.it", "sinkhole report", $msg);
```

There are also a shell version and other minor variations.

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FRR configuration

Announce the sinkholed addresses with BGP (the same script configures them on a local interface):

```
router bgp 12637
 neighbor CORE peer-group
 neighbor CORE remote-as 12637
 neighbor 192.0.2.1 peer-group CORE
 neighbor 192.0.2.2 peer-group CORE
 !
 address-family ipv4 unicast
  redistribute connected route-map CONNECTED-TO-BGP

route-map CONNECTED-TO-BGP permit 200
 match ip address prefix-list CONNECTED-SINKHOLE

ip prefix-list CONNECTED-SINKHOLE permit 192.0.2.42/32
```

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Why are we doing this?

- General principle of reporting intrusions to customers!
- Upselling security consulting.

IP sinkholing also benefits transit customers.

Early detection by sinkholing greatly decreased the related security incidents!

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Some statistics

The current database

- 11 "campaigns"
- 1010 sinkholed IP addresses
- 44 sinkholed domains (hosted on Cloudflare)

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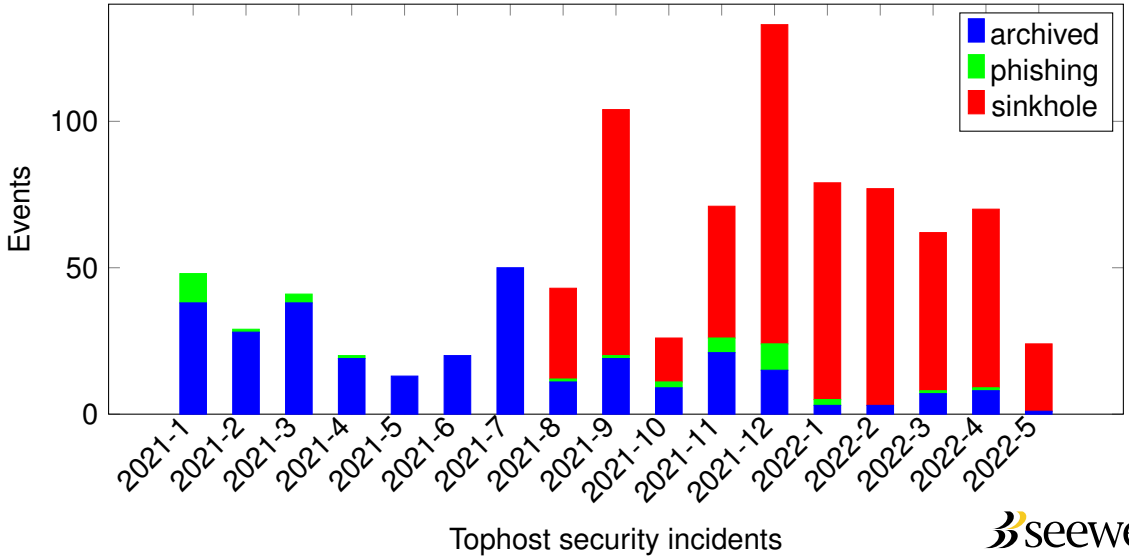
Some statistics



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Obfuscation: eval and base64_decode

```php
<?php
eval(base64_decode('ZWNobyAiaGVsbG9cbiIK')));

eval(base64_decode(str_rot13('MJAbolNvnTIfoT9povVX')));

eval(gzuncompress(base64_decode(str_rot13(('...')))));

eval(gzuncompress(base64_decode(some_decrypter(('...')))));
```

Deobfuscation:

```
s/eval/echo/
```

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Obfuscation: variables as function names

```php
<?php
$f='str_rot13';
eval($f('rpub "uryyb jbeyq!\a";'));
```

Deobfuscation:

```
echo
```

Obfuscation: (hidden) create_function

```php
<?php
$f = 'create_function';
$a = '$foo';
$c = 'echo str_rot13($foo);';
$ff = $f($a, $c);
$ff("uryyb jbeyq!\n");
```

Deobfuscation:

```
echo
```

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Obfuscation: printf escaping

```
<?php
${"\x47\x4c\x4f\x42AL\x53"}["x\x64\x72\x75\x74\x6a\x6ff\x72\x68"]="rg\x78";
${"\x47L\x4fB\x41L\x53"}["a\x65\x67o\x76\x68\x6a\x79i"]="\x6e\x65w";
${"GLO\x42ALS"}["\x65\x72b\x6f\x62\x6a\x68\x75k\x69\x72"]="\x6f1\x64\x5fb";
${"\x47\x4c\x4fB\x41L\x53"}["\x6bpeuu\x72\x75\x6a\x66\x67"]
="\x6f\x6c\x64\x5fa";
${"\x47\x4cOB\x41\x4c\x53"}["\x67mb\x73iv\x6b\x61\x79\x6bjx"]
="m\x79\x73e\x6c\x66";
${"\x47\x4cOB\x41LS"}["\x72\x66j\x74\x75\x63\x69\x77\x68\x6eo"]
="\x6ee\x77\x5f\x62";
```

Deobfuscation:

Filter with `printf`.

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Obfuscation: junk comments

```
<?php
eval/*a*/(/*dru*//*dnh*/(/*y*/rawurldecode/*u*/(/*up9s*/$_pbtfh1/*z*/)/*9*/
^ substr/*a3vs2*/(/*1*/str_repeat/*uq7r*/(/*4k*/$_elijqf,
/*9y*/(/*g3*/strlen/*muyx*/(/*6yk8*/$_pbtfh1/*th8vc*/)/*vdgp*//strlen/*vx0*/
(/*21g*/$_elijqf/*8xa9*/)/*c5*//*er*/)/*cf3dz*/ + 1/*en*/)/*8*/, 0,
strlen/*oit01*/(/*e*/$_pbtfh1/*pr8*/)/*dcf51*//*n*/)/*7rtw*//*6*/)/*y*//*w*/
)/*c0su*/;
```

Deobfuscation:

```
php -w
```

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Obfuscation: arrays

```php
<?php
$OOOOOO="%71%77%65%72%74%79%75%69%6f%70...%21%2a%7c%2b%2c";
$O=urldecode($OOOOOO);
${$O{18}.$O{7}.$O{24}.$O{2}.$O{50}.$O{8}}="2336";

if (!preg_match($O{63}.$O{79}.$O{15}.$O{4}.$O{4}.$O{9}.
$O{83}.$O{62}.$O{83}.$O{63}.$O{83}.$O{63}.$O{63}.$O{11}. $O{7}, $OOOooooOO))
{

function oooOOoOOoOOoO($OOOooooOO, $OOooO = 1, $OOOOOooO = NULL, $OOOOooooOOO =
array()) {
```

Deobfuscation:

```php
echo; var_dump;
```

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Obfuscation: goto

```
<?php
goto pn_FT; AHvKp: goto a5HmB; Wf8RV: function kk2qW($nujoa) { goto RS2q9;
PAhG4: goto n2edC; goto X8pnw; ctNPy: return $G4JcL; goto ov1Qt; B875x:
$cW69A = 0; goto HWHHd; d4dHM: ogkPy: goto fil8P; fil8P: $cW69A += 2; goto
PAhG4; O1mPS: $G4JcL .= pack("C", hexdec(substr($nujoa, $cW69A, 2))); goto
d4dHM; HWHHd: n2edC: goto psCVH; RS2q9: $PE3gP = strlen(trim($nujoa)); goto
sW_Kh; X8pnw: iChD_: goto ctNPy; sW_Kh: $G4JcL = ''; goto B875x; psCVH: if
(!($cW69A < $PE3gP)) { goto iChD_; } goto O1mPS; ov1Qt: } goto AHvKp; pn_FT:
error_reporting(0); goto Wf8RV; a5HmB: echo(kK2qw("65766..."));
```

Deobfuscation:

Reorder...

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<?php /* tjwlltii akhmhcij */error_reporting(0);ini_set("display_errors", 0);if(
!defined('lmhelqpg')){define('lmhelqpg',__FILE__);if(!function_exists("<94><e3>
<a7><9a><e0><c5><f3><f6>")){function <a0>
<a7><82>,$<ae><a4><8f><f3><b2>
<ab>,$ü<cc><e4><f6><a3>
><f8><f2>
=$<bf><96><ad><9e><9d><86>
=$ű<d3><fa><c9>
=$<8b><82><b7><8f><ea><88><e0>
=$<b8><86><83><f
e>
=$<b8><93><c8>
=$<b8><98><a4><82><91><b0><d5>
1<de>5CFBÕA==');$<d4><fa><b4><8f><f2><a1><ac>
<c5>('B<ac>B<a8>');$<8a><96><9f><c8>
');$
d6>GB<ce>==');$<a7><82><83><98><ee><bd>
<a2>==');$<87>9>
A==');$<bf><b1><83><99><ae><b4><a3>
Ц<d4><f0><f0><ca>GA<f2>');$<82><96><fb><b3><e7><af>
a2><83><c5>('<9a><dc><f0>
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Any questions?

https://www.linux.it/~md/text/sinkholing-hibb-s2022.pdf

(Google ... Marco d'Itri ... I feel lucky)

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