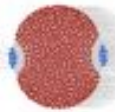
Seeing the Invisible

Finding Fingerprints on Encrypted Traffic

Adel "0x4D31" Ka.
CHCon'19 / Kawaiicon'19, New Zealand

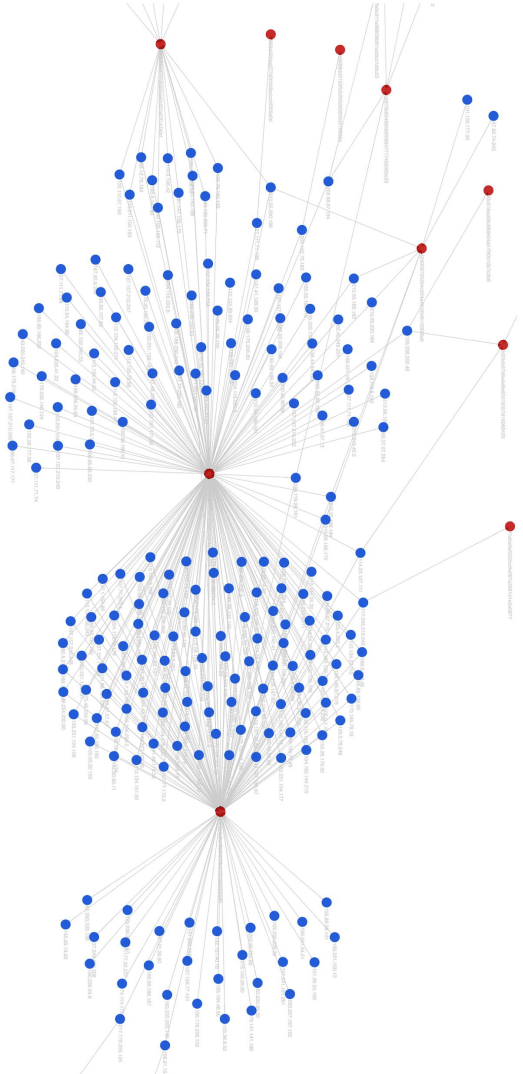


$whoami

> 0x4D31

- Honeynet Project
- Detecting badness at *
- Hobbyist {astro}photographer
- github.com/0x4D31

* Google



The Problem

```
3c 15 c2 df 54 9c 5c 03  39 cd 0a b2 08 00 45 00
02 68 97 fb 00 00 7b 06  43 47 d8 3a c8 63 c0 a8
01 07 01 bb e4 47 62 6c  fc 90 6b e8 b5 af 80 18
00 f0 c4 a7 00 00 01 01  08 0a a5 29 25 03 2f 00
88 ad 17 03 03 01 f1 fd  21 b0 64 fc fc de 2c 79
25 ee ca f5 83 92 f7 2c  36 c3 d0 9a 61 c9 dd d8
45 b4 ce 7d 46 55 2e 6f  ec 14 c8 a7 a1 b9 d8 3d
a6 39 9e 00 84 e2 00 5c  4d 6d f5 22 d7 3c 92 dd
b2 be 5d ab e5 a3 08 70  c9 bb bc e6 89 61 ad 45
c5 77 e6 bf f0 45 f3 56  a1 85 ae bb 9c ce 89 3e
10 92 7e c7 15 35 ed ab  d3 72 3c 1e c5 bd c4 8b
87 7c 02 50 7e a5 fd 96  58 60 a3 d8 80 b6 e5 fe
2b 17 74 77 c0 75 6e 19  d5 ed 96 39 96 c8 97 dd
40 05 ac 28 ed 38 34 41  ec 63 a3 0a b7 da 95 10
86 79 e1 38 f2 b8 54 41  f9 d1 34 04 3e 94 a3 d0
b1 6f b8 75 b0 e5 27 c5  17 6a 5d c8 f3 93 be c3
9a 5c 98 65 6f af ec d7  3f 52 89 b9 46 90 7d 21
35 72 f4 63 2f 4d 35 2a  56 b3 e8 ad 7f d8 2f 5b
6f b6 8d 34 12 da e1 a5  cd 66 57 98 8e ed 65 2e
71 8a dc fe 8f 44 5b 40  70 ab d2 f4 94 00 a7 36
e3 a2 43 3d d1 af 25 97  98 6b 49 3c 8f 2b 40 61
bf af 7d 89 85 7a 05 c8  1d f0 d6 0c c9 86 8d f4
2a 52 fd e4 17 4b d5 cd  79 13 f5 51 8d c4 7e 54
54 ae e5 c4 f6 40 26 02  cf 2e c3 81 fc 15 4e a6
14 73 b6 a8 ea 93 d0 2c  6d a1 e2 c5 58 b5 63 e7
e0 ab c9 c9 7a ad dc be  8a 62 44 77 3c db 64 c0
42 d4 b9 94 39 56 87 72  60 eb 3e 1c be 9f 98 a2
8b e5 34 62 01 ac 5a 5b  d4 89 6c 27 d8 41 f8 7c
7b 34 95 81 0c 8f 32 72  4b e3 ae 3e fd 66 53 a7
bd 13 d9 03 af d1 99 17  9e 55 95 2b c0 07 91 64
3b b9 0e ea f4 d6 ca a4  dc 82 04 bd b3 53 b6 99
79 88 c9 00 f4 ea f7 9b  40 45 82 a0 51 e5 fc 91
3b 74 74 89 2d c6 26 e8  b5 18 46 b3 37 df fb 8a
```

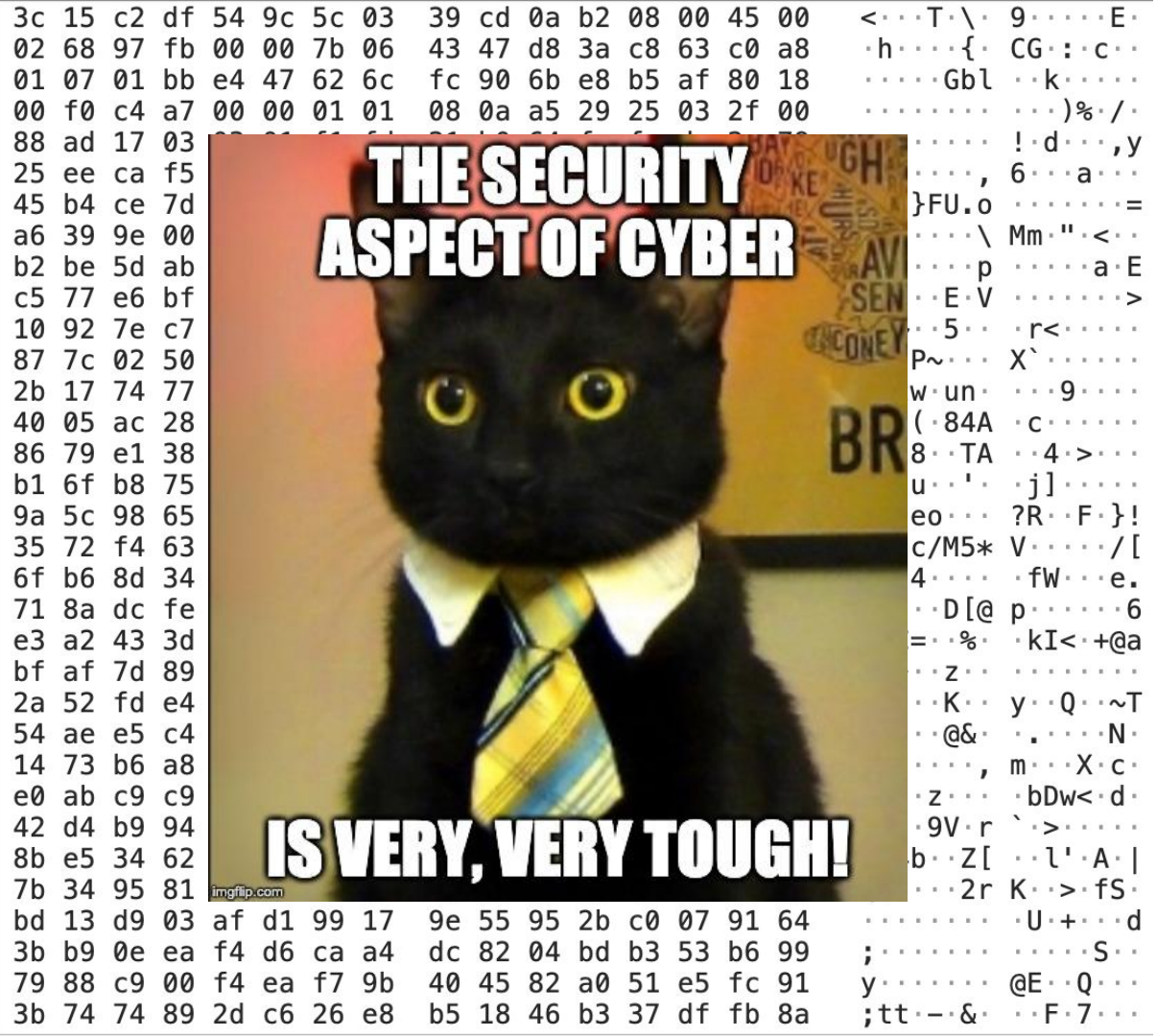
Encrypted Traffic

visibility

```
3c 15 c2 df 54 9c 5c 03  39 cd 0a b2 08 00 45 00   <···T·\· 9·····E·
02 68 97 fb 00 00 7b 06  43 47 d8 3a c8 63 c0 a8   ·h····{· CG·:·c··
01 07 01 bb e4 47 62 6c  fc 90 6b e8 b5 af 80 18   ·····Gbl ··k·····
00 f0 c4 a7 00 00 01 01  08 0a a5 29 25 03 2f 00   ········ ···)%·/·
88 ad 17 03 03 01 f1 fd  21 b0 64 fc fc de 2c 79   ········ !·d···,y
25 ee ca f5 83 92 f7 2c  36 c3 d0 9a 61 c9 dd d8   %·····, 6···a···
45 b4 ce 7d 46 55 2e 6f  ec 14 c8 a7 a1 b9 d8 3d   E··}FU.o ·······=
a6 39 9e 00 84 e2 00 5c  4d 6d f5 22 d7 3c 92 dd   ·9·····\ Mm·"·<··
b2 be 5d ab e5 a3 08 70  c9 bb bc e6 89 61 ad 45   ··]····p ·····a·E
c5 77 e6 bf f0 45 f3 56  a1 85 ae bb 9c ce 89 3e   ·w···E·V ·······>
10 92 7e c7 15 35 ed ab  d3 72 3c 1e c5 bd c4 8b   ··~··5·· ·r<·····
87 7c 02 50 7e a5 fd 96  58 60 a3 d8 80 b6 e5 fe   ·|·P~··· X`······
2b 17 74 77 c0 75 6e 19  d5 ed 96 39 96 c8 97 dd   +·tw·un· ···9····
40 05 ac 28 ed 38 34 41  ec 63 a3 0a b7 da 95 10   @··(·84A ·c······
86 79 e1 38 f2 b8 54 41  f9 d1 34 04 3e 94 a3 d0   ·y·8··TA ··4·>···
b1 6f b8 75 b0 e5 27 c5  17 6a 5d c8 f3 93 be c3   ·o·u··'· ·j]·····
9a 5c 98 65 6f af ec d7  3f 52 89 b9 46 90 7d 21   ·\·eo··· ?R··F·}!
35 72 f4 63 2f 4d 35 2a  56 b3 e8 ad 7f d8 2f 5b   5r·c/M5* V·····/[
6f b6 8d 34 12 da e1 a5  cd 66 57 98 8e ed 65 2e   o··4···· ·fW···e.
71 8a dc fe 8f 44 5b 40  70 ab d2 f4 94 00 a7 36   q····D[@ p·····6
e3 a2 43 3d d1 af 25 97  98 6b 49 3c 8f 2b 40 61   ··C=··%· ·kI<·+@a
bf af 7d 89 85 7a 05 c8  1d f0 d6 0c c9 86 8d f4   ··}··z·· ········
2a 52 fd e4 17 4b d5 cd  79 13 f5 51 8d c4 7e 54   *R···K·· y··Q··~T
54 ae e5 c4 f6 40 26 02  cf 2e c3 81 fc 15 4e a6   T····@&· ·.····N·
14 73 b6 a8 ea 93 d0 2c  6d a1 e2 c5 58 b5 63 e7   ·s·····, m···X·c·
e0 ab c9 c9 7a ad dc be  8a 62 44 77 3c db 64 c0   ····z··· ·bDw<·d·
42 d4 b9 94 39 56 87 72  60 eb 3e 1c be 9f 98 a2   B···9V·r `·>·····
8b e5 34 62 01 ac 5a 5b  d4 89 6c 27 d8 41 f8 7c   ··4b··Z[ ··l'·A·|
7b 34 95 81 0c 8f 32 72  4b e3 ae 3e fd 66 53 a7   {4····2r K··>·fS·
bd 13 d9 03 af d1 99 17  9e 55 95 2b c0 07 91 64   ········ ·U·+···d
3b b9 0e ea f4 d6 ca a4  dc 82 04 bd b3 53 b6 99   ;·······  ·····S··
79 88 c9 00 f4 ea f7 9b  40 45 82 a0 51 e5 fc 91   y·······  @E··Q···
3b 74 74 89 2d c6 26 e8  b5 18 46 b3 37 df fb 8a   ;tt·-·&·  ··F·7···
```

Encrypted Traffic

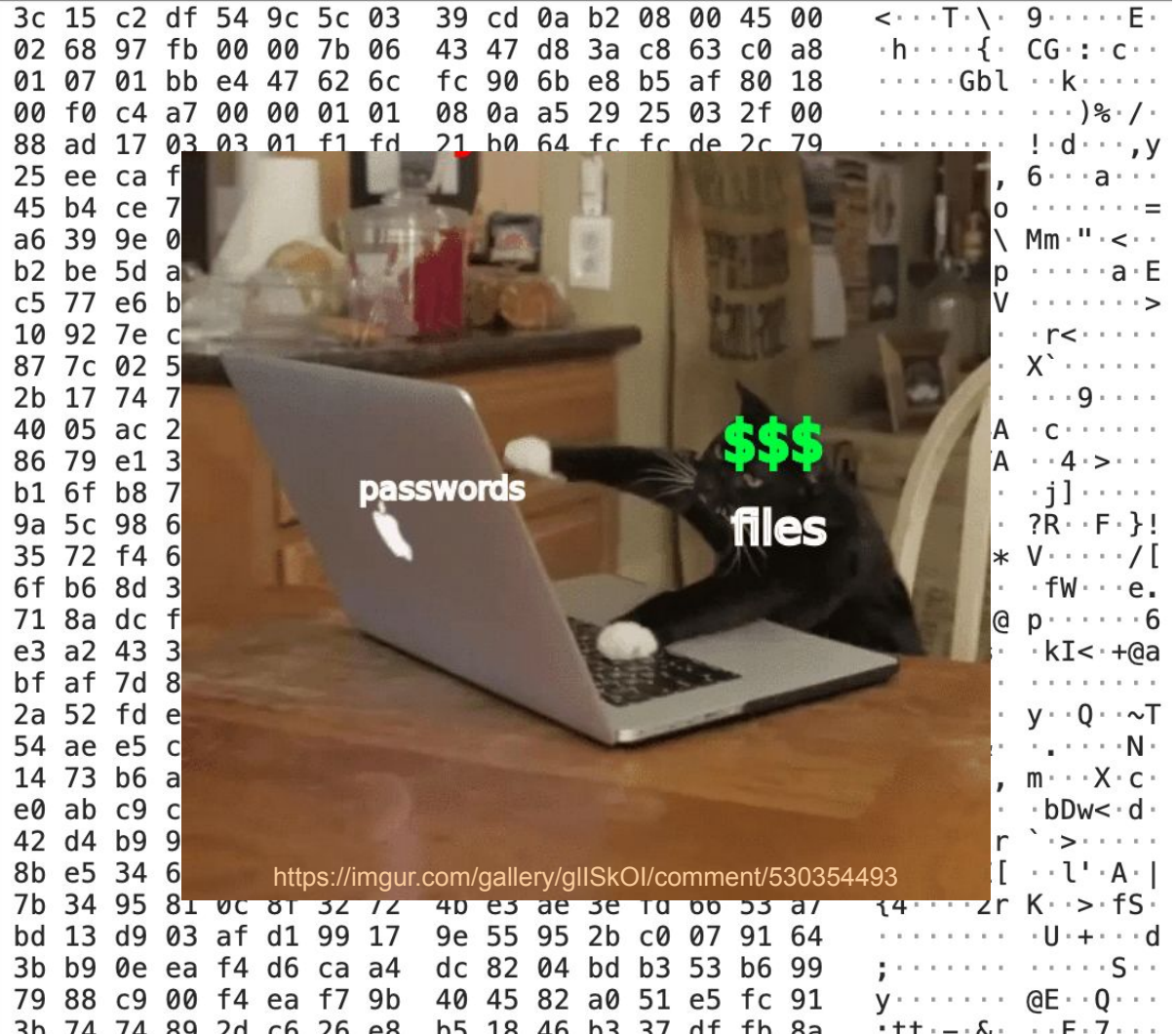
good traffic?



Encrypted Traffic

('o_o')

good traffic?



Encrypted Traffic

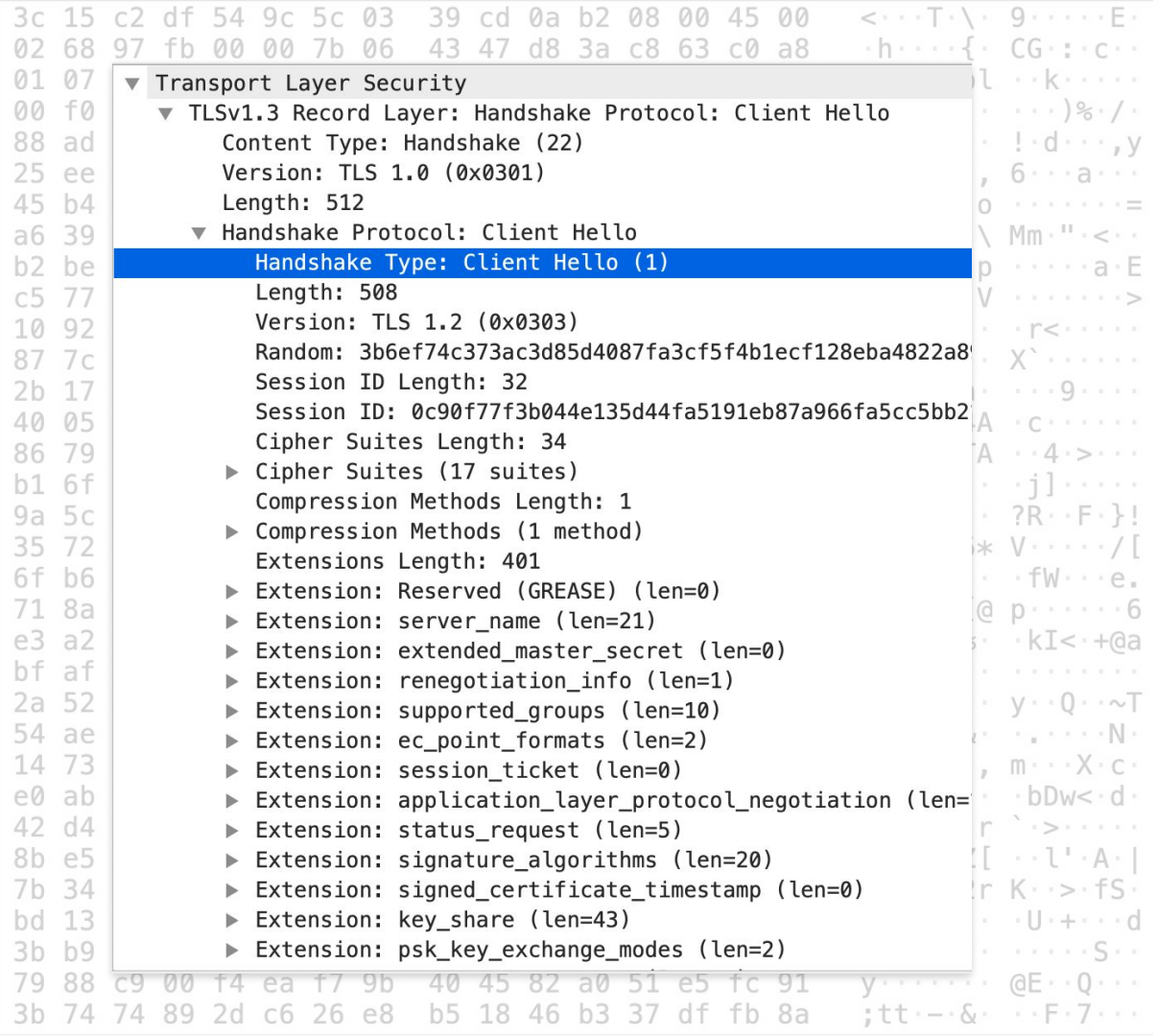
(•_•)

bad traffic?

```
3c 15 c2 df 54 9c 5c 03  39 cd 0a b2 08 00 45 00  <···T·\· 9·····E·
02 68 97 fb 00 00 7b 06  43 47 d8 3a c8 63 c0 a8  ·h····{· CG·:·c··
01 07 01 bb e4 47 62 6c  fc 90 6b e8 b5 af 80 18  ·····Gbl ··k·····
00 f0 c4 a7 00 00 01 01  08 0a a5 29 25 03 2f 00  ········ ···)%·/·
88 ad 17 03 03 01 f1 fd  21 b0 64 fc fc de 2c 79  ········ !·d···,y
25 ee ca f5 83 92 f7 2c  36 c3 d0 9a 61 c9 dd d8  %·····, 6···a···
45 b4 ce 7d 46 55 2e 6f  ec 14 c8 a7 a1 b9 d8 3d  E··}FU.o ·······=
a6 39 9e 00 84 e2 00 5c  4d 6d f5 22 d7 3c 92 dd  ·9·····\ Mm·"·<··
b2 be 5d ab e5 a3 08 70  c9 bb bc e6 89 61 ad 45  ··]····p ·····a·E
c5 77 e6 bf f0 45 f3 56  a1 85 ae bb 9c ce 89 3e  ·w···E·V ·······>
10 92 7e c7 15 35 ed ab  d3 72 3c 1e c5 bd c4 8b  ··~··5·· ·r<·····
87 7c 02 50 7e a5 fd 96  58 60 a3 d8 80 b6 e5 fe  ·|·P~··· X`······
2b 17 74 77 c0 75 6e 19  d5 ed 96 39 96 c8 97 dd  +·tw·un· ···9····
40 05 ac 28 ed 38 34 41  ec 63 a3 0a b7 da 95 10  @··(·84A ·c······
86 79 e1 38 f2 b8 54 41  f9 d1 34 04 3e 94 a3 d0  ·y·8··TA ··4·>···
b1 6f b8 75 b0 e5 27 c5  17 6a 5d c8 f3 93 be c3  ·o·u··'· ·j]·····
9a 5c 98 65 6f af ec d7  3f 52 89 b9 46 90 7d 21  ·\·eo··· ?R··F·}!
35 72 f4 63 2f 4d 35 2a  56 b3 e8 ad 7f d8 2f 5b  5r·c/M5* V·····/[
6f b6 8d 34 12 da e1 a5  cd 66 57 98 8e ed 65 2e  o··4···· ·fW···e.
71 8a dc fe 8f 44 5b 40  70 ab d2 f4 94 00 a7 36  q····D[@ p·····6
e3 a2 43 3d d1 af 25 97  98 6b 49 3c 8f 2b 40 61  ··C=··%· ·kI<·+@a
bf af 7d 89 85 7a 05 c8  1d f0 d6 0c c9 86 8d f4  ··}··z·· ········
2a 52 fd e4 17 4b d5 cd  79 13 f5 51 8d c4 7e 54  *R···K·· y··Q··~T
54 ae e5 c4 f6 40 26 02  cf 2e c3 81 fc 15 4e a6  T····@&· ·.····N·
14 73 b6 a8 ea 93 d0 2c  6d a1 e2 c5 58 b5 63 e7  ·s·····, m···X·c·
e0 ab c9 c9 7a ad dc be  8a 62 44 77 3c db 64 c0  ····z··· ·bDw<·d·
42 d4 b9 94 39 56 87 72  60 eb 3e 1c be 9f 98 a2  B···9V·r `·>·····
8b e5 34 62 01 ac 5a 5b  d4 89 6c 27 d8 41 f8 7c  ··4b··Z[ ··l'·A·|
7b 34 95 81 0c 8f 32 72  4b e3 ae 3e fd 66 53 a7  {4····2r K··>·fS·
bd 13 d9 03 af d1 99 17  9e 55 95 2b c0 07 91 64  ········ ·U·+···d
3b b9 0e ea f4 d6 ca a4  dc 82 04 bd b3 53 b6 99  ;·······  ·····S··
79 88 c9 00 f4 ea f7 9b  40 45 82 a0 51 e5 fc 91  y·······  @E··Q···
3b 74 74 89 2d c6 26 e8  b5 18 46 b3 37 df fb 8a  ;tt·-·&·  ··F·7···
```

Encrypted Traffic

Any Clues!? 🤔



Encrypted Traffic

Any Clues!? 🤔

Network Metadata & Fingerprints

Can we use

Network Metadata & Fingerprints to

profile the attackers and tools,

Can we use

Network Metadata & Fingerprints to

discover hidden connections,

Can we use

Network Metadata & Fingerprints to

possibly **find new evasion methods!?**

Background

Fingerprinting

fingerprinTLS

Browser Fingerprinting

HASSH

JA3

SSL/TLS Fingerprinting

sslhaf

OS Fingerprinting

p0f

Application Fingerprinting

httprint

Cryptographic protocols need to negotiate some parameters in **clear-text !**

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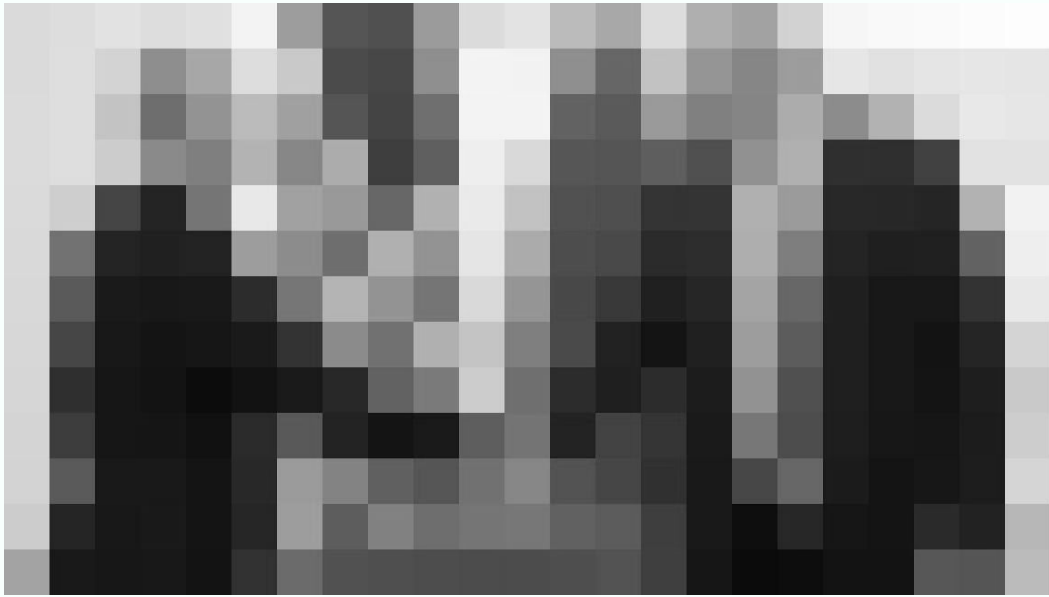
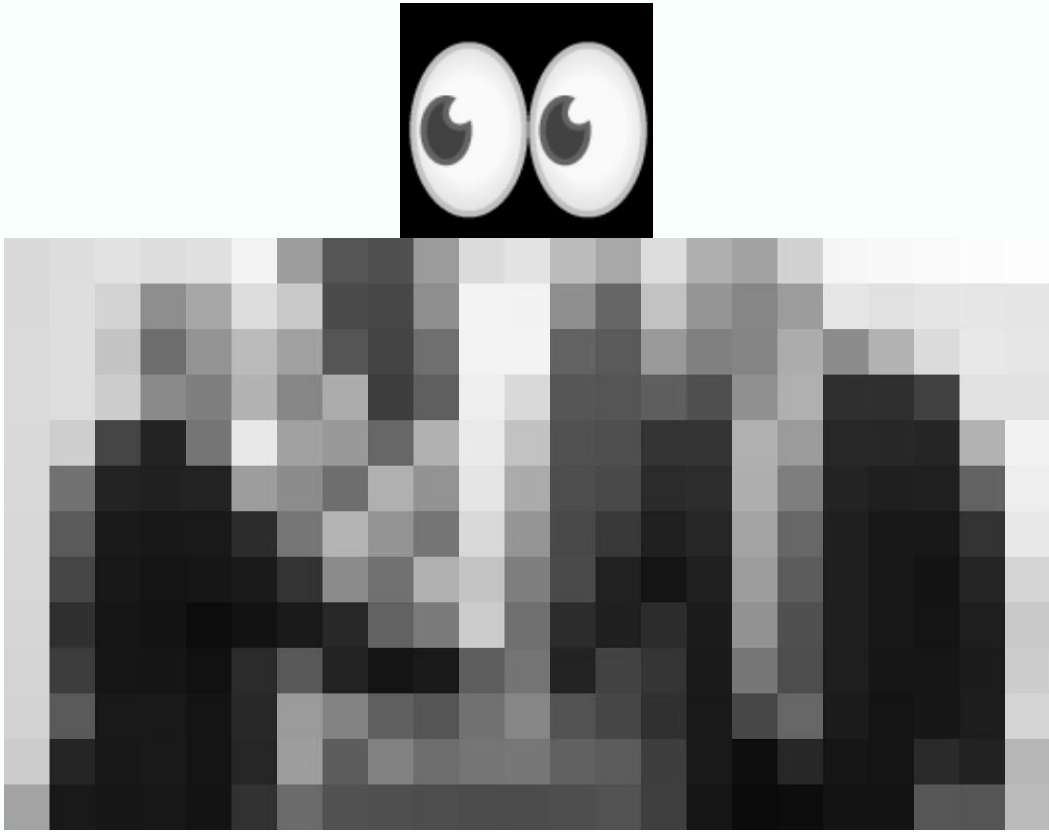


Cryptographic protocols need to negotiate some parameters in **clear-text !**



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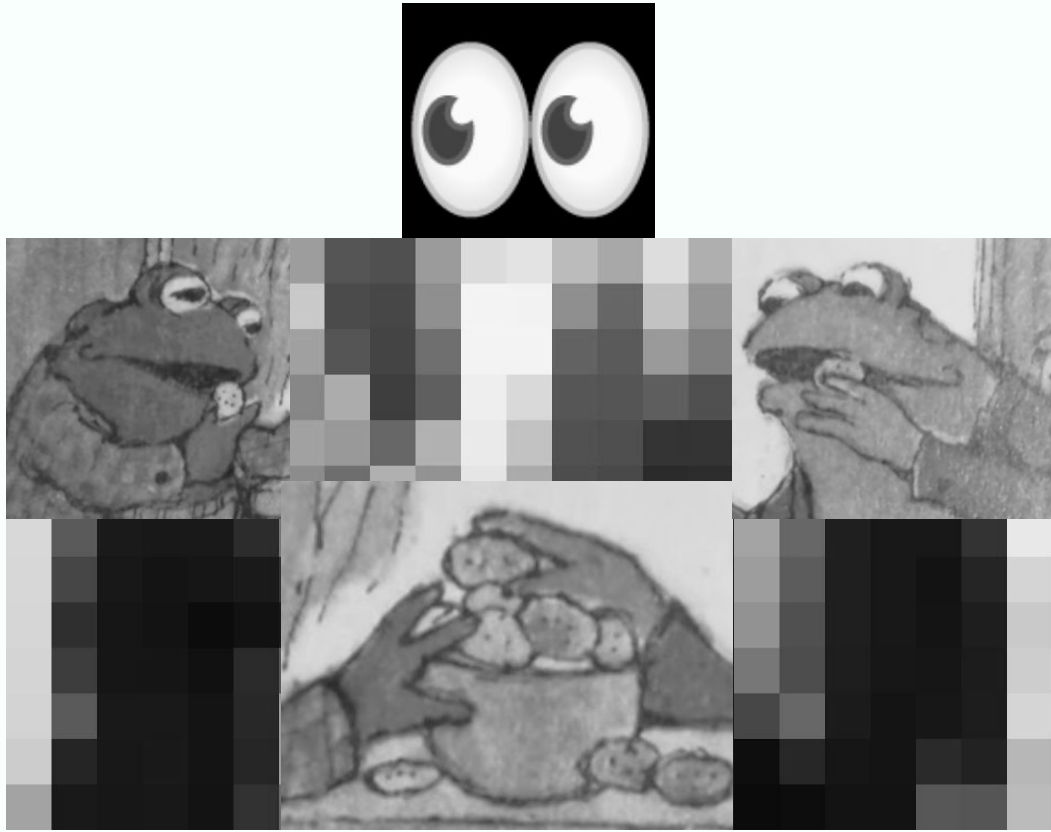
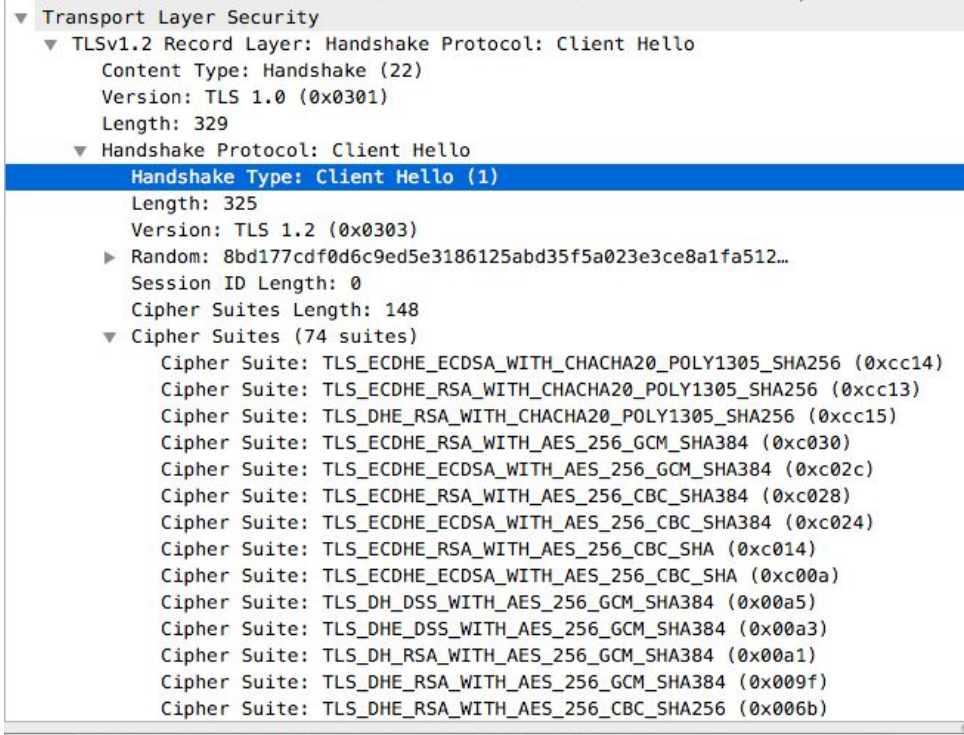


Frog and Toad is illustrated by Arnold Lobel

TLS Client/Server Fingerprinting

using client/server Hello messages



TLS

<client Hello>

SSL/TLS Handshake

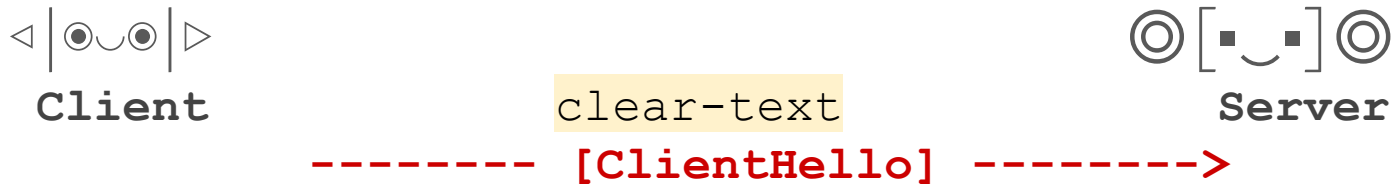
- Message Flow for a SSL/TLS Handshake

Client

Server

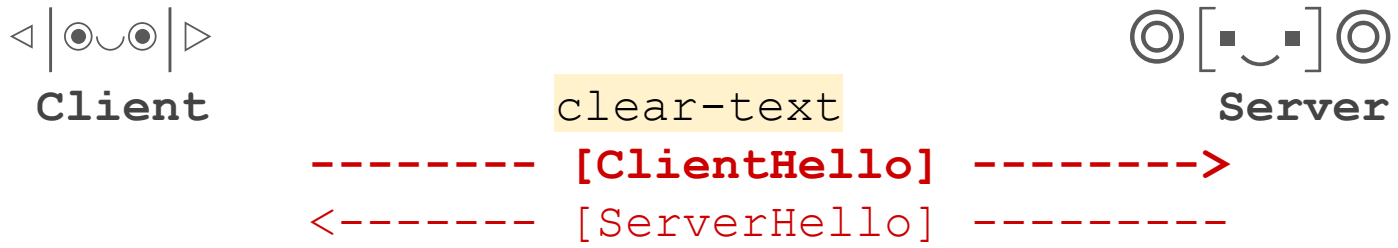
SSL/TLS Handshake

- Message Flow for a SSL/TLS Handshake



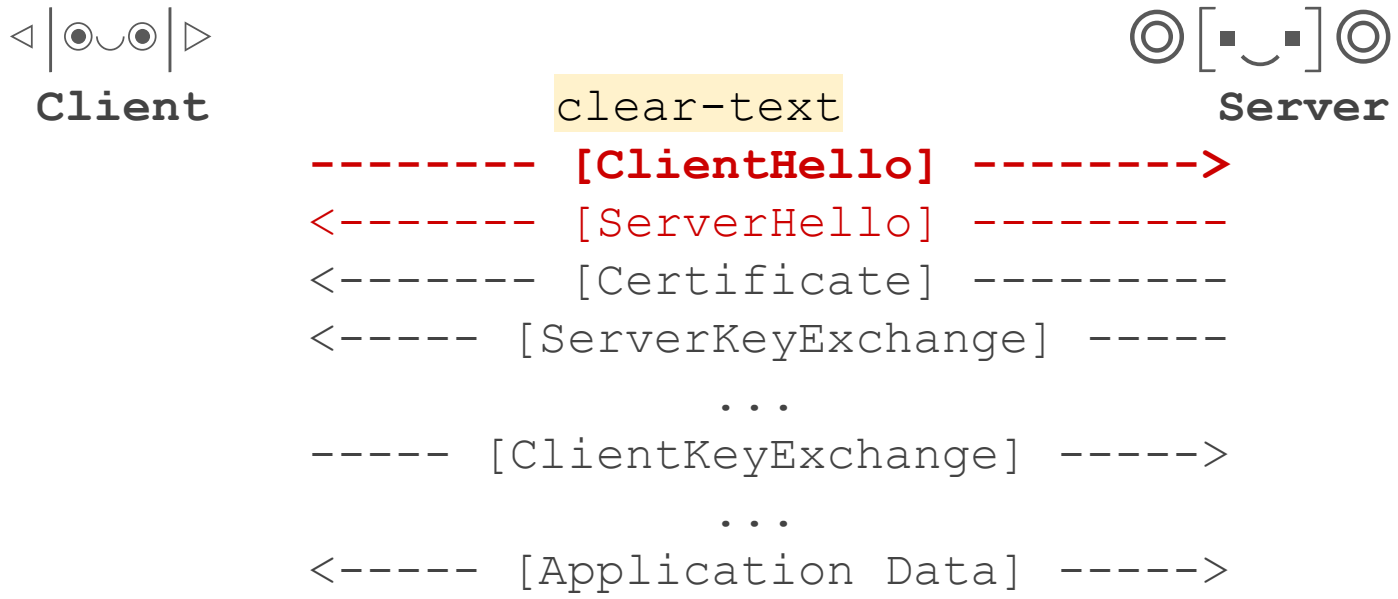
SSL/TLS Handshake

- Message Flow for a SSL/TLS Handshake



SSL/TLS Handshake

- Message Flow for a SSL/TLS Handshake



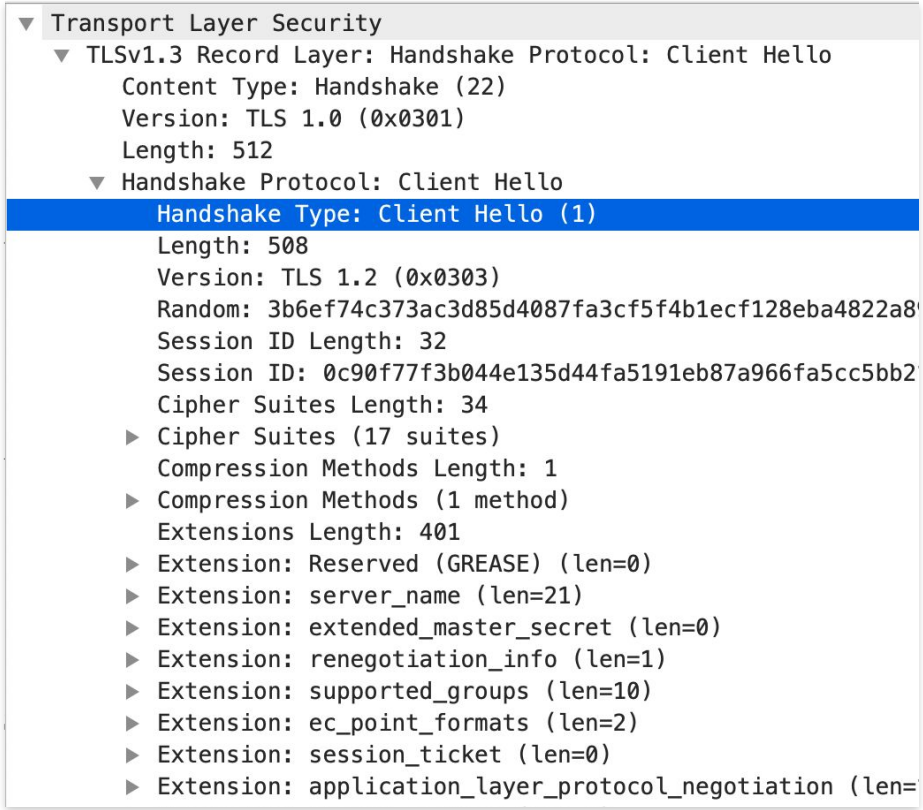
SSL/TLS ClientHello

```
struct {
      ProtocolVersion client_version;
      Random random;
      SessionID session_id;
      CipherSuite cipher_suites<2..2^16-2>;
      Compression Method compression_methods<1..2^8-1>;
      select (extensions_present) {
          case false:
              struct {};
          case true:
              Extension extensions<0..2^16-1>;
      };
} ClientHello;
```

Reference: https://tools.ietf.org/html/rfc5246

SSL/TLS ClientHello

```
struct {
      ProtocolVersion client_vers
      Random random;
      SessionID session_id;
      CipherSuite cipher_suites<2
      Compression Method compress
      select (extensions_present)
          case false:
              struct {};
          case true:
              Extension extension
      };
} ClientHello;
```



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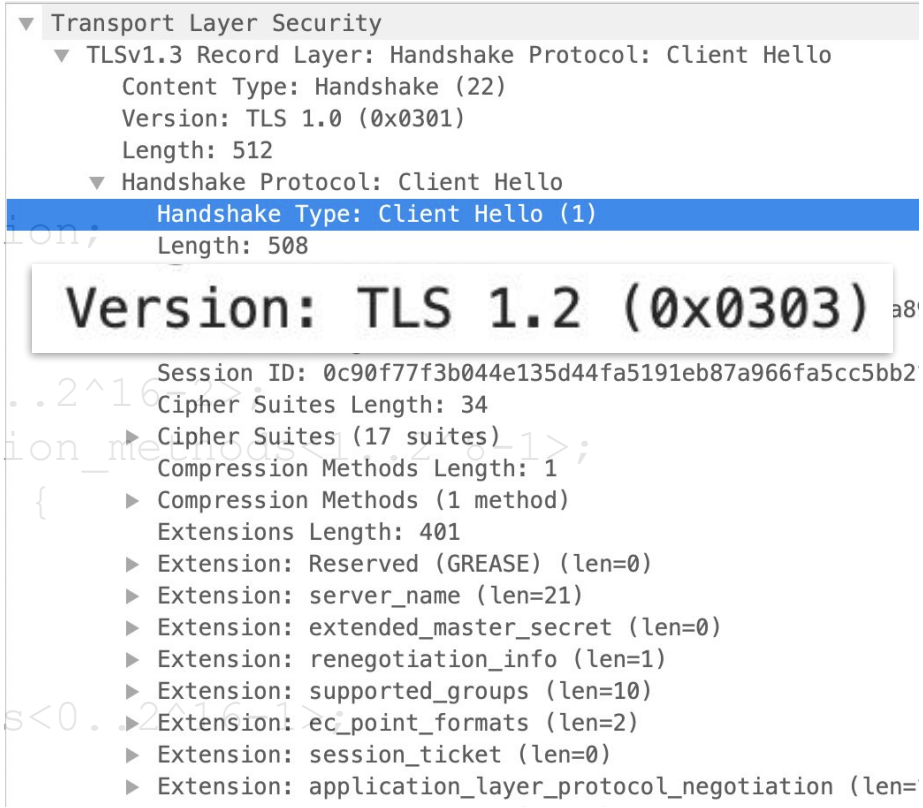

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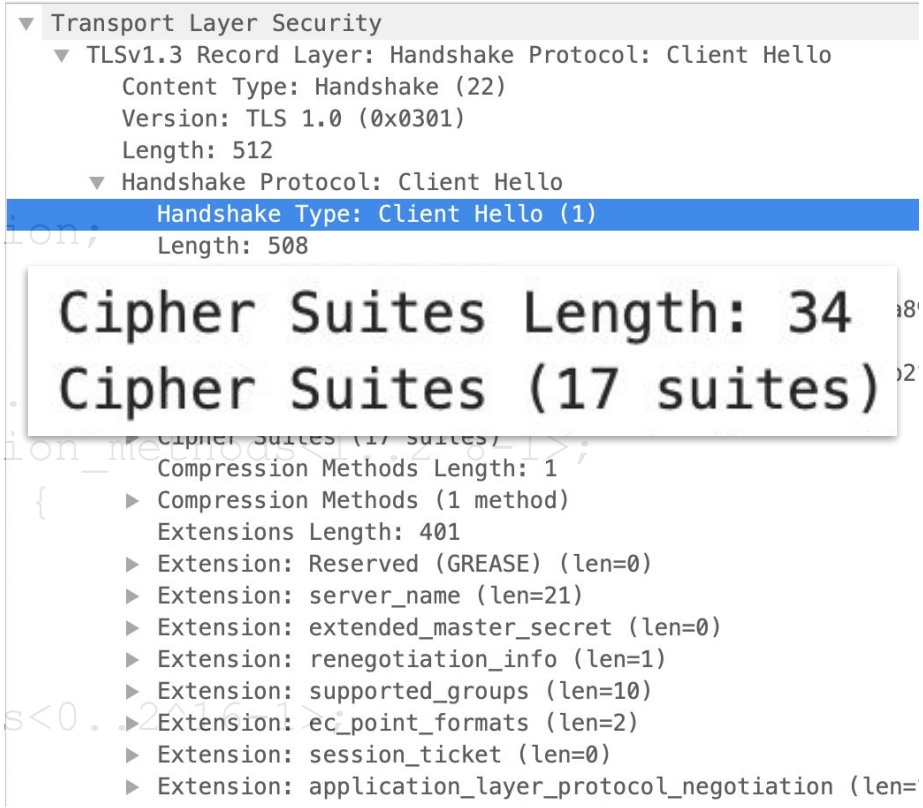
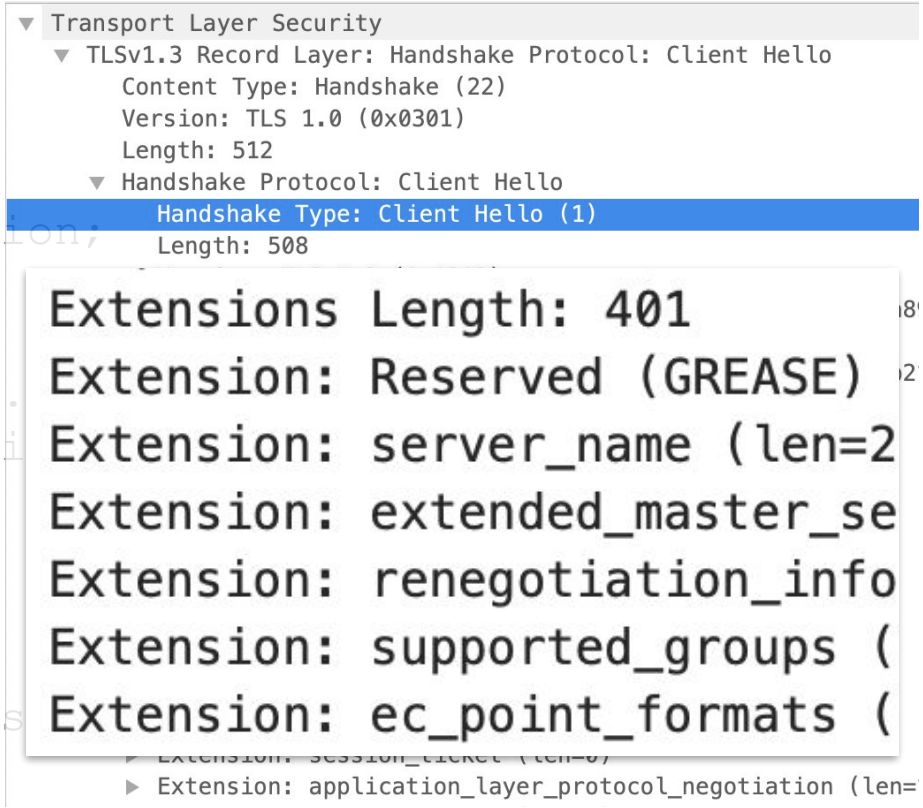


Reference: https://tools.ietf.org/html/rfc5246

The cipher suite list is in order of the **client's preference** !

SSL/TLS ClientHello

```
struct {
      ProtocolVersion client_version;
      Random random;
      SessionID session_id;
      CipherSuite cipher_suites<2..
      Compression Method compressi
      select (extensions_present)
          case false:
              struct {};
          case true:
              Extension extensions
      };
} ClientHello;
```



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TLS Fingerprinting

sslhaf [1]

FingerprinTLS [2]

JA3 [3]

[1] **sslhaf**: Ivan Ristic, https://blog.ivanristic.com/2009/06/http-client-fingerprinting-using-ssl-handshake-analysis.html, *2009*
[2] ***fingerprinTLS****: Lee Brother*ston, https://blog.squarelemon.com/tls-fingerprinting/, *2015*
[3] ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

TLS Fingerprinting

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TLS Fingerprinting

sslhaf [1]

FingerprinTLS [2]

JA3 [3]

Easy to produce!
Can be easily shared!

[1] **sslhaf**: Ivan Ristic, https://blog.ivanristic.com/2009/06/http-client-fingerprinting-using-ssl-handshake-analysis.html, *2009*
[2] ***fingerprinTLS****: Lee Brother*ston, https://blog.squarelemon.com/tls-fingerprinting/, *2015*
[3] ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

Concatenate the decimal value of

SSL Version

771,

* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

Concatenate the decimal value of

Cipher Suites

771,4865-4866-4867-49195-49199-49196-49200-52393-52392-49171-49172-156-157-47-53-10,

* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

Concatenate the decimal value of

Extensions

771,4865-4866-4867-49195-49199-49196-49200-52393-52392-49171-49172-156-157-47-53-10,0-23-65281-10-11-35-16-5-13-18-51-45-43-27-21,

* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

Concatenate the decimal value of

Elliptic Curves / Supported Groups

771,4865-4866-4867-49195-49199-49196-49200-52393-52392-49171-49172-156-157-47-53-10,0-23-65281-10-11-35-16-5-13-18-51-45-43-27-21,29-23-24,

* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

Concatenate the decimal value of

EC Point Formats

771,4865-4866-4867-49195-49199-49196-49200-52393-52392-49171-49172-156-157-47-53-10,0-23-65281-10-11-35-16-5-13-18-51-45-43-27-21,29-23-24,0

* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

771,4865-4866-4867-49195-49199-49196-49200-52393-52392-49171-49172-156-157-47-53-10,0-23-65281-10-11-35-16-5-13-18-51-45-43-27-21,29-23-24,0

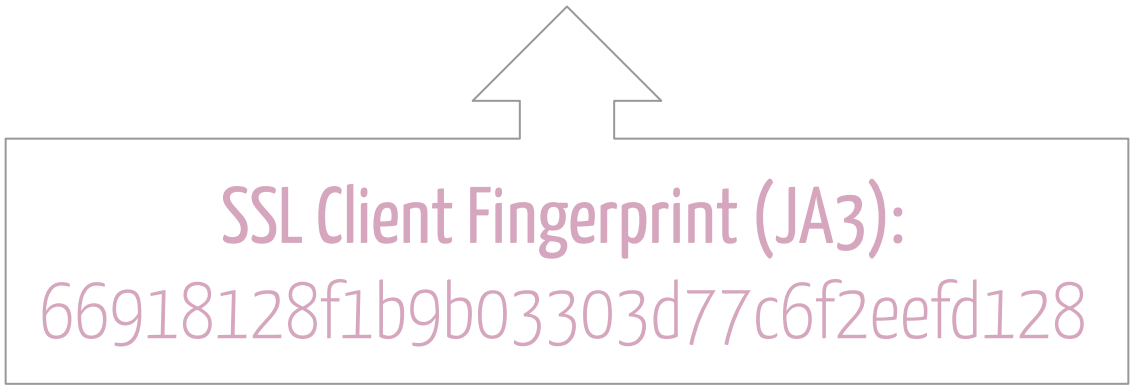
* ***JA3**: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

Fingerprinting TLS client/servers with JA3 *

* ***JA3**: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41, *2017*

Fingerprinting TLS client/servers with JA3 *

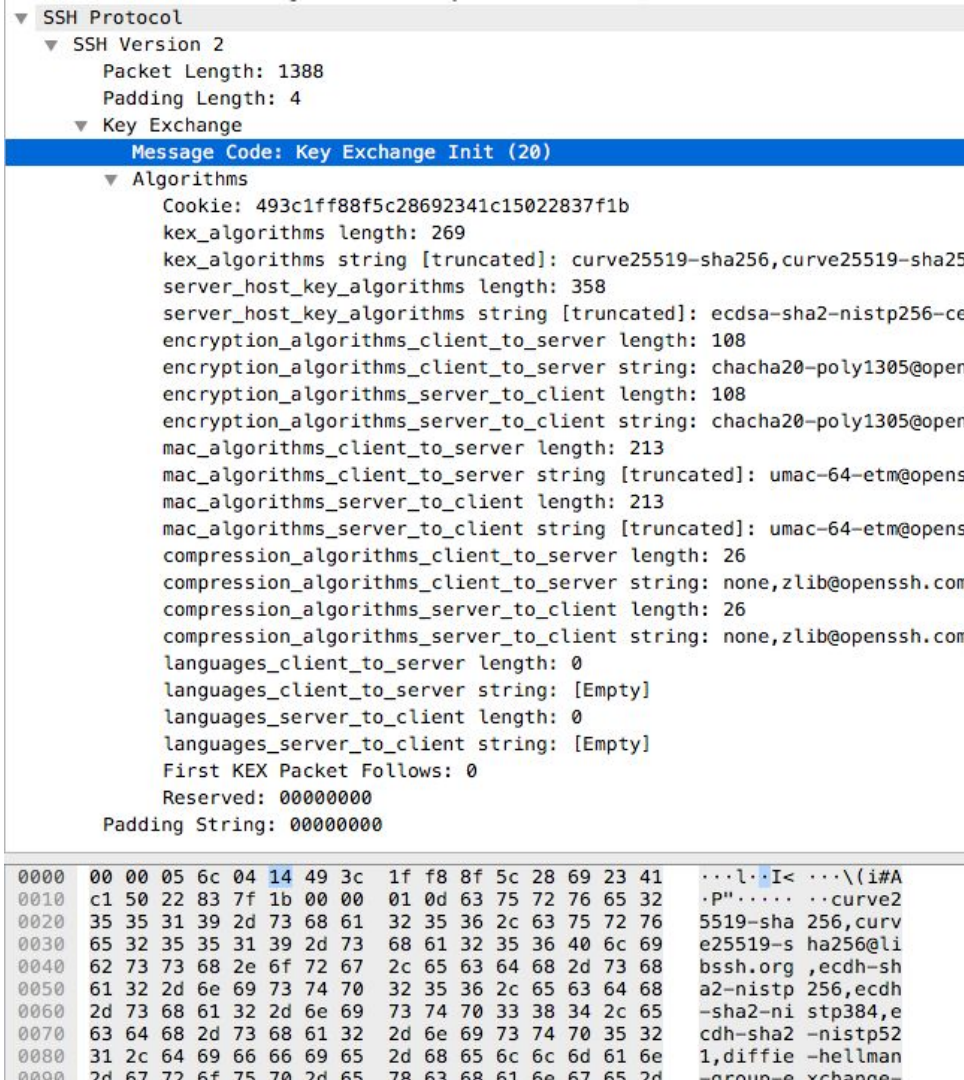
the TLS Client is probably
Chrome!



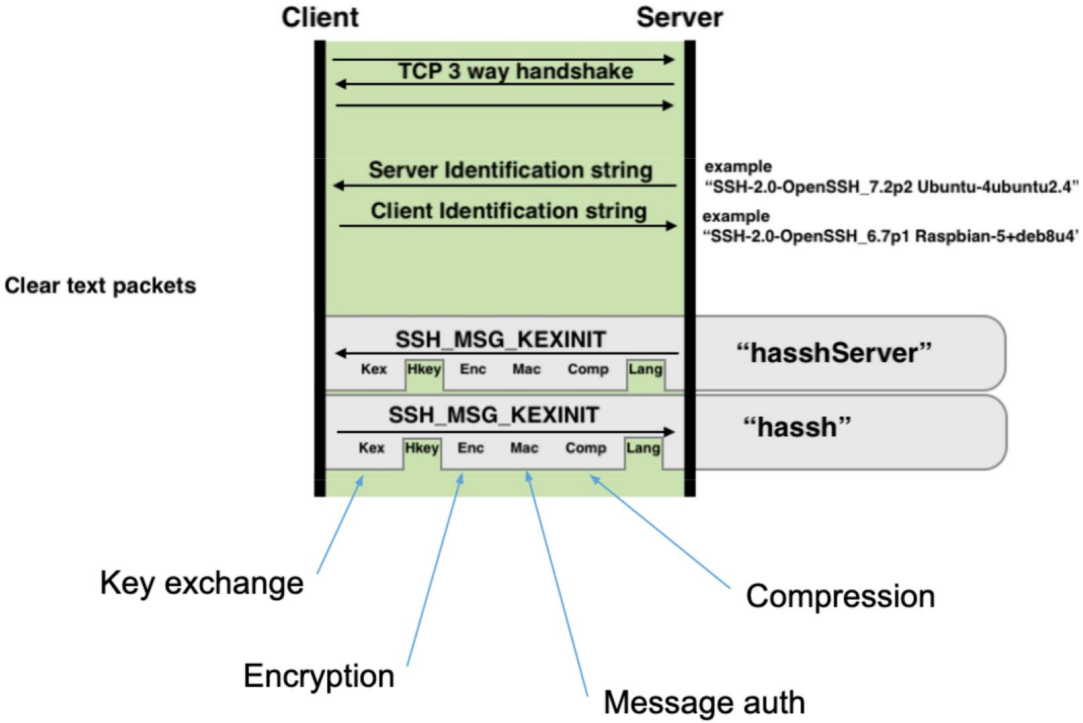
* ***JA3****: John Althouse, Jeff Atkinson, Josh Atkins,* https://engineering.salesforce.com/open-sourcing-ja3-92c9e53c3c41*, 2017*

SSH Client/Server Fingerprinting

using SSH_MSG_KEXINIT messages



HASSH Profiling Method



* ***HASSH***: *Ben Reardon, Adel Karimi, https://github.com/salesforce/hassh, 2018*

HASSH - examples

hassh(**Ncrack**) =

55a77ae9728654f1d4240a29287dc296

hassh(**CobaltStrike_SSH-client**) =

a7a87fbe86774c2e40cc4a7ea2ab1b3c

* ***HASSH***: *Ben Reardon, Adel Karimi, https://github.com/salesforce/hassh, 2018*

HASSH - nmap script

```
 % nmap --script ssh-hassh.nse -p 22  192.168.10.136

Starting Nmap 7.60 ( https://nmap.org ) at 2019-09-30 20:45 PDT
Nmap scan report for mikrotik.planethacker.net (192.168.10.136)
Host is up (0.0063s latency).

PORT   STATE SERVICE
22/tcp open  ssh
| ssh-hassh:
|   Server Identification String: SSH-2.0-ROSSSH
|   hasshServer: 592ac2fb1645c3dc26ede0a59cd46957
|_  hasshServer Guess: SSH-2.0-ROSSSH (100%)
```

https://github.com/0x4D31/hassh-utils

* ***HASSH**: Ben Reardon, Adel Karimi, https://github.com/salesforce/hassh, 2018*

Detecting

SSH Honeypots 

Cowrie - bad news

hasshServer	string	06046964c022c6407d15a27b12a6a4fb
hasshServerAlgorithms	string	curve25519-s nistp384,ecd sha512,diffie- group14-sha poly1305@op gcm@openss 256-etm@op etm@openss sha2-512,hm

```
t.supportedCiphers = [
    b'aes128-ctr',
    b'aes192-ctr',
    b'aes256-ctr',
    b'aes128-cbc',
    b'3des-cbc',
    b'blowfish-cbc',
    b'cast128-cbc',
    b'aes192-cbc',
    b'aes256-cbc'
]
t.supportedPublicKeys = [b'ssh-rsa', b'ssh-dss']
t.supportedMACs = [b'hmac-md5', b'hmac-sha1']
t.supportedCompressions = [b'zlib@openssh.com', b'zlib', b'none']
```

Cowrie - bad news

hasshServer	string	06046964c022c6407d15a27b12a6a4fb
hasshServerAlgorithms	string	curve25519-s nistp384,ecds sha512-diffie etm@openss sha2-512,hm

hassh(**Cowrie**) = a0fd4bcb0e72b4b21232a486825b6742

```
t.supportedCiphers = [
    b'aes128-ctr',
    b'aes192-ctr',
    b'aes192-cbc',
    b'aes256-cbc'
]
t.supportedPublicKeys = [b'ssh-rsa', b'ssh-dss']
t.supportedMACs = [b'hmac-md5', b'hmac-sha1']
t.supportedCompressions = [b'zlib@openssh.com', b'zlib', b'none']
```

Cowrie - good news

Expose SSH key exchange parameters in config file (#1051)

```
* Added support for getting encryption, compression, and hash methods from
config file
```

master (#1051) 1.6.0

mayanksha authored and **micheloosterhof** committed on Mar 14

52 src/cowrie/ssh/factory.py

```
@@ -107,21 +107,45 @@ def buildProtocol(self,
                log.msg("No moduli, no diffi
sha256")
            t.supportedKeyExchanges = ske
```

```
-       # Reorder supported ciphers to resemble current openssh more
-       t.supportedCiphers = [
-           b'aes128-ctr',
-           b'aes192-ctr',
-           b'aes256-ctr',
-           b'aes128-cbc',
-           b'3des-cbc',
```

```
109
110 +       try:
111 +           t.supportedCiphers = [bytearray(i, 'utf-8') for i in
    CONFIG.get('ssh', 'ciphers').split(',')]
112 +       except NoOptionError:
113 +           # Reorder supported ciphers to resemble current openssh more
114 +           t.supportedCiphers = [
115 +               b'aes128-ctr',
116 +               b'aes192-ctr',
```

Cowrie - HASSH support

Fingerprinting

RDP

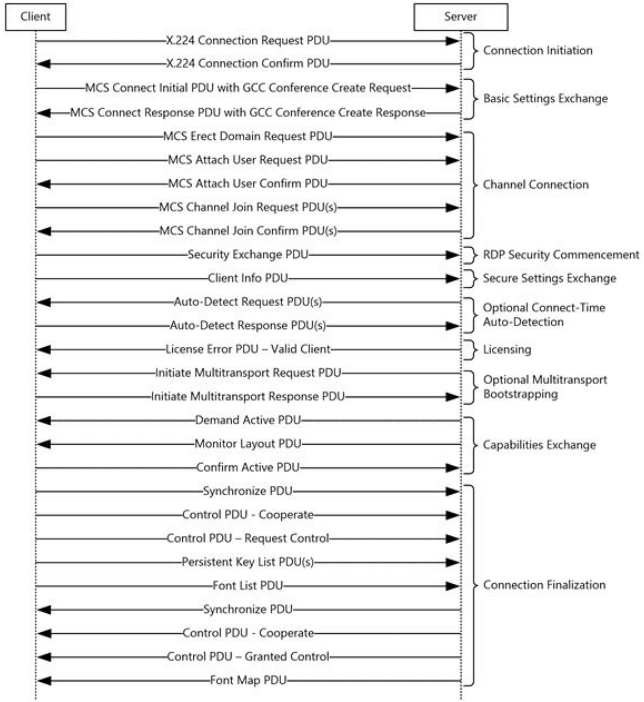
Remote Desktop Protocol

Fingerprinting

RDP

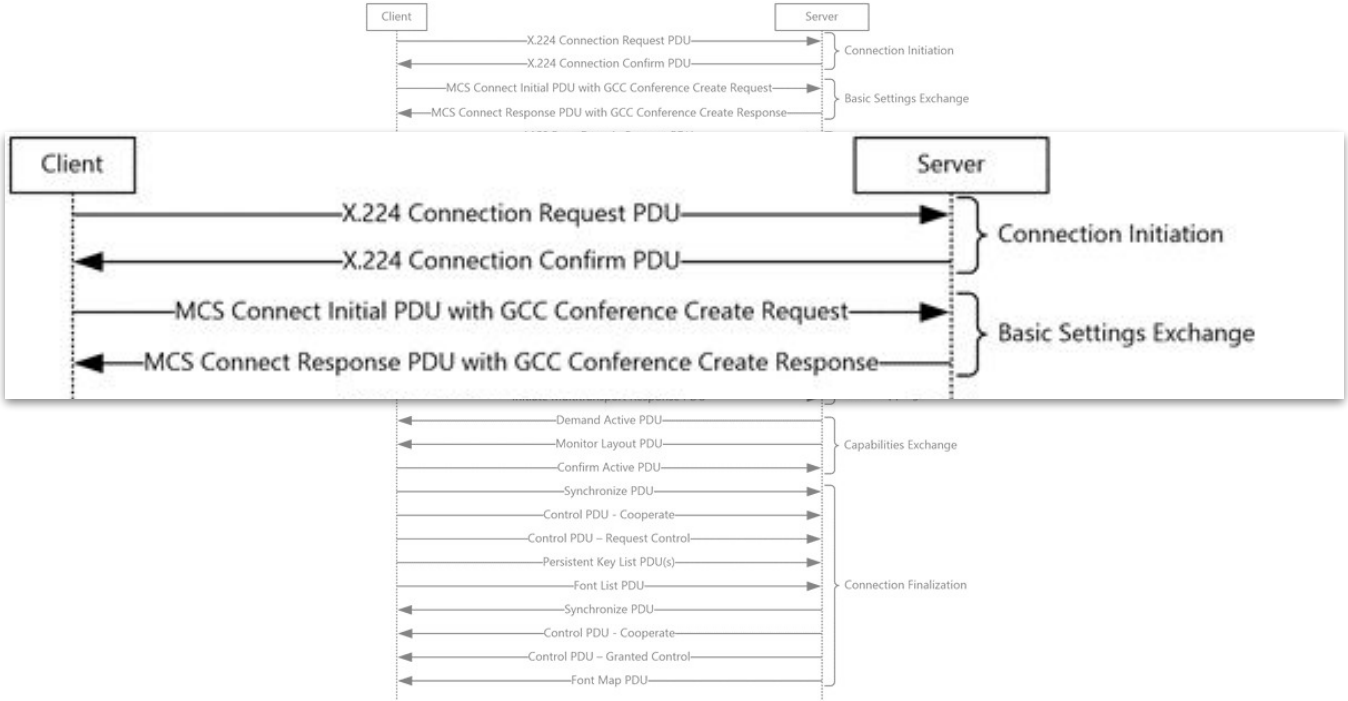
Remote Desktop Protocol

RDP Connection Sequence



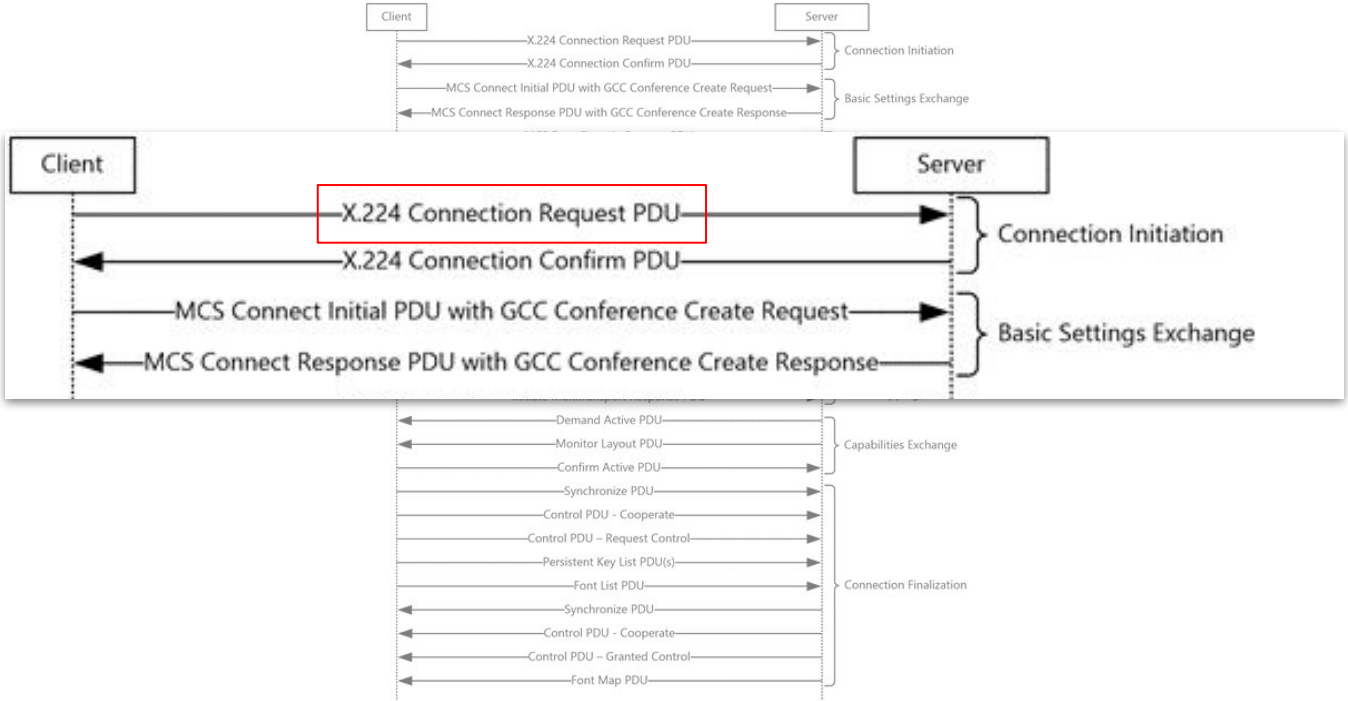
Ref: Microsoft, “Remote Desktop Protocol: Basic Connectivity and Graphics Remoting”

RDP Connection Sequence



Ref: Microsoft, “Remote Desktop Protocol: Basic Connectivity and Graphics Remoting”

RDP Connection Sequence



Ref: Microsoft, “Remote Desktop Protocol: Basic Connectivity and Graphics Remoting”

Client X.224 Connection Request

No.	Time	Source	src port	Destination	dst port	Protocol	Info
4	0.000483	192.168.56.1	54809	192.168.56.101	3389	RDP	Cookie: mstshash=g1ghrsx2, Negotiate Request

```
▶ Frame 4: 112 bytes on wire (896 bits), 112 bytes captured (896 bits)
▶ Ethernet II, Src: 0a:00:27:00:00:00 (0a:00:27:00:00:00), Dst: PcsCompu_ed:80:9c (08:00:27:ed:80:9c)
▶ Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.101
▶ Transmission Control Protocol, Src Port: 54809, Dst Port: 3389, Seq: 1, Ack: 1, Len: 46
▶ TPKT, Version: 3, Length: 46
▶ ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
▼ Remote Desktop Protocol
    Routing Token/Cookie: Cookie: mstshash=g1ghrsx2
    Type: RDP Negotiation Request (0x01)
  ▶ Flags: 0x00
    Length: 8
  ▼ requestedProtocols: 0x00000001, TLS security supported
      .... .... .... .... .... .... .... ...1 = TLS security supported: True
      .... .... .... .... .... .... .... ..0. = CredSSP supported: False
      .... .... .... .... .... .... .... 0... = Early User Authorization Result PDU supported: False
```

```
0000  08 00 27 ed 80 9c 0a 00  27 00 00 00 08 00 45 00   ··'····· '·····E·
0010  00 62 00 00 40 00 40 06  48 df c0 a8 38 01 c0 a8   ·b··@·@· H···8···
0020  38 65 d6 19 0d 3d 74 62  2c b8 47 b8 d1 5c 80 18   8e···=tb ,·G··\··
0030  10 15 d8 bb 00 00 01 01  08 0a 3e 33 b1 9c 00 00   ········ ··>3····
0040  00 00 03 00 00 2e 29 e0  00 00 00 00 00 43 6f 6f   ·····.)· ·····Coo
0050  6b 69 65 3a 20 6d 73 74  73 68 61 73 68 3d 67 31   kie: mst shash=g1
0060  67 68 72 73 78 32 0d 0a  01 00 08 00 01 00 00 00   ghrsx2·· ········
```

Client X.224 Connection Request

Cookie: mstshash=g1ghrsx2

No.	Time	Source	src port	Destination	dst port	Protocol	Info
4	0.000483	192.168.56.1	54809	192.168.56.101	3389	RDP	Cookie: mstshash=g1ghrsx2, Negotiate Request

```
▶ Frame 4: 112 bytes on wire (896 bits), 112 bytes captured (896 bits)
▶ Ethernet II, Src: 0a:00:27:00:00:00 (0a:00:27:00:00:00), Dst: PcsCompu_ed:80:9c (08:00:27:ed:80:9c)
▶ Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.101
▶ Transmission Control Protocol, Src Port: 54809, Dst Port: 3389, Seq: 1, Ack: 1, Len: 46
▶ TPKT, Version: 3, Length: 46
▶ ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
▼ Remote Desktop Protocol
    Routing Token/Cookie: Cookie: mstshash=g1ghrsx2
    Type: RDP Negotiation Request (0x01)
  ▶ Flags: 0x00
    Length: 8
  ▼ requestedProtocols: 0x00000001, TLS security supported
      .... .... .... .... .... .... .... ...1 = TLS security supported: True
      .... .... .... .... .... .... .... ..0. = CredSSP supported: False
      .... .... .... .... .... .... .... 0... = Early User Authorization Result PDU supported: False
```

```
0000  08 00 27 ed 80 9c 0a 00  27 00 00 00 08 00 45 00   ··'····· '·····E·
0010  00 62 00 00 40 00 40 06  48 df c0 a8 38 01 c0 a8   ·b··@·@· H···8···
0020  38 65 d6 19 0d 3d 74 62  2c b8 47 b8 d1 5c 80 18   8e···=tb ,·G··\··
0030  10 15 d8 bb 00 00 01 01  08 0a 3e 33 b1 9c 00 00   ········ ··>3····
0040  00 00 03 00 00 2e 29 e0  00 00 00 00 00 43 6f 6f   ·····.)· ·····Coo
0050  6b 69 65 3a 20 6d 73 74  73 68 61 73 68 3d 67 31   kie: mst shash=g1
0060  67 68 72 73 78 32 0d 0a  01 00 08 00 01 00 00 00   ghrsx2·· ········
```

Client X.224 Connection Request

requestedProtocols: 0x00000001

No.	Time	Source	src port	Destination	dst port	Protocol	Info
4	0.000483	192.168.56.1	54809	192.168.56.101	3389	RDP	Cookie: mstshash=g1ghrsx2, Negotiate Request

```
▶ Frame 4: 112 bytes on wire (896 bits), 112 bytes captured (896 bits)
▶ Ethernet II, Src: 0a:00:27:00:00:00 (0a:00:27:00:00:00), Dst: PcsCompu_ed:80:9c (08:00:27:ed:80:9c)
▶ Internet Protocol Version 4, Src: 192.168.56.1, Dst: 192.168.56.101
▶ Transmission Control Protocol, Src Port: 54809, Dst Port: 3389, Seq: 1, Ack: 1, Len: 46
▶ TPKT, Version: 3, Length: 46
▶ ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
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    Routing Token/Cookie: Cookie: mstshash=g1ghrsx2
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  ▶ Flags: 0x00
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  ▼ requestedProtocols: 0x00000001, TLS security supported
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      .... .... .... .... .... .... .... 0... = Early User Authorization Result PDU supported: False
```

```
0000  08 00 27 ed 80 9c 0a 00  27 00 00 00 08 00 45 00   ··'····· '·····E·
0010  00 62 00 00 40 00 40 06  48 df c0 a8 38 01 c0 a8   ·b··@·@· H···8···
0020  38 65 d6 19 0d 3d 74 62  2c b8 47 b8 d1 5c 80 18   8e···=tb ,·G··\··
0030  10 15 d8 bb 00 00 01 01  08 0a 3e 33 b1 9c 00 00   ········ ··>3····
0040  00 00 03 00 00 2e 29 e0  00 00 00 00 00 43 6f 6f   ·····.)· ·····Coo
0050  6b 69 65 3a 20 6d 73 74  73 68 61 73 68 3d 67 31   kie: mst shash=g1
0060  67 68 72 73 78 32 0d 0a  01 00 08 00 01 00 00 00   ghrsx2·· ········
```

There are **two** **RDP Security** modes

Standard

There are **two** **RDP Security** modes

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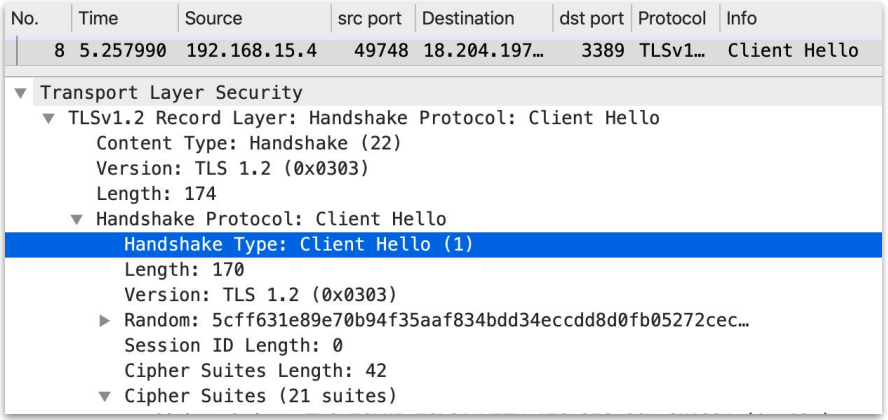
Enhanced

There are **two** **RDP Security** modes

ᕕ(ò_óˇ)



Enhanced RDP Security

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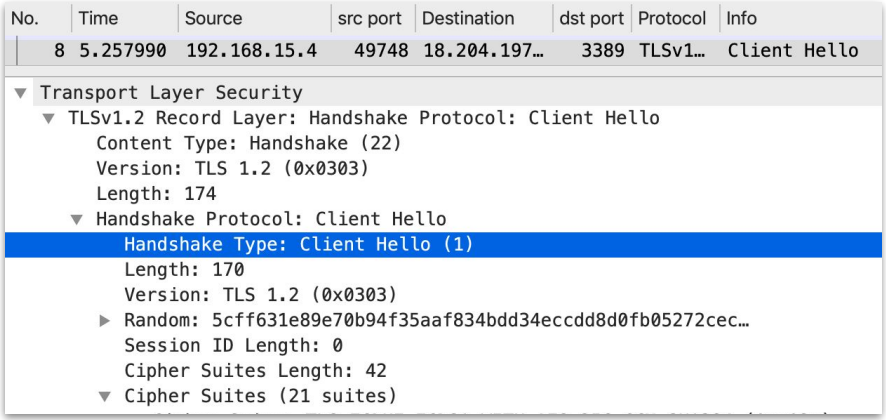
Supports the following *external security protocols*:

TLS 1.0 / TLS 1.1 / TLS 1.2 / CredSSP / RDSTLS



Enhanced RDP Security

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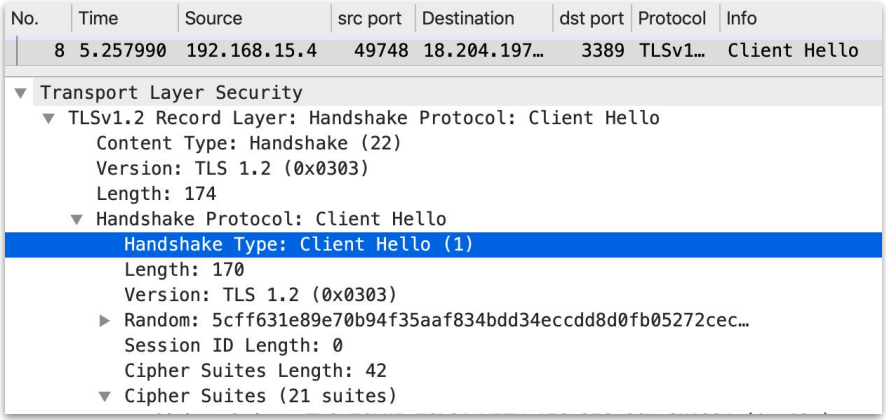
TLS 1.0 / TLS 1.1 / TLS 1.2 / CredSSP / RDSTLS



Enhanced RDP Security

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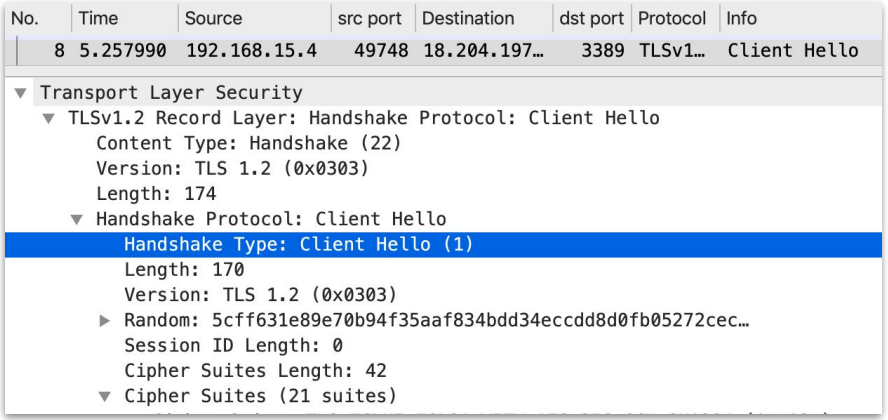
TLS 1.0 / TLS 1.1 / TLS 1.2 / CredSSP / RDSTLS



Enhanced RDP Security

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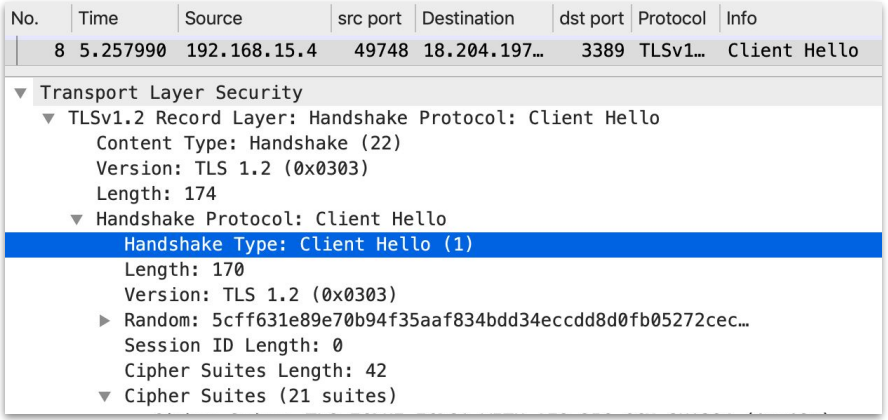
TLS 1.0 / TLS 1.1 / TLS 1.2 / CredSSP / RDSTLS

TLS



Enhanced RDP Security

ᕦ(ò_óˇ)

TLS 1.0 / TLS 1.1 / TLS 1.2 / CredSSP / RDSTLS

TLS → Can be fingerprinted with **JA3**

Enhanced RDP Security

ᕦ(ò_óˇ)

Windows XP SP3; RDC 6.1.7600

JA3: c8a0d08d2cbee4bed7cd90e47588ab9b

Search this file...

os version	rdp client	ja3	ja3Algorithms
Windows XP SP3	RDC 6.1.7600	c8a0d08d2cbee4bed7cd90e47588ab9b	769,4-5-10-9-100-98-3-6-19
Windows 2012	RDC 6.2.9200	bc2874f25a8254edb36147c151527cfa	771,49192-49191-49172-49
Windows 2008r2	RDC 6.3.9600	e6a4e2358d4eee6122403f3cb835bcbd	771,49192-49191-49172-49
Windows 2012r2	RDC 6.3.9600	3e686105164b7c9a4cbd59142f18a4e7	771,49192-49191-49172-49
Windows 7	RDC 6.3.9600	d54b3eb800cbeccf99fd5d5cdcd7b5b5	771,49192-49191-49172-49
Windows 2016	RDC 10.0.14393	67e3d18fd9dddbbc8eca65f7dedac674	771,49196-49195-49200-49
Windows 2019	RDC 10.0.17763	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
Windows 10	RDC 10.0.17134	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
macOS	Microsoft Remote Desktop	e4d448cdfe06dc1243c1eb026c74ac9a	771,255-49196-49195-4918
macOS	FreeRDP	75fb48a465416d66291fb52a733d4787	769,49172-49162-57-56-55-
macOS	rdpy, rdesktop, python	e2121ae1544cd5acae048d03505068a6	769,49162-49172-57-49161
macOS	robertdavidgraham/rdpscan	0b3e989a2ad13829ab8d65d132480e41	769,49172-49162-57-56-65
macOS	pupy's rdp module	f330c48fc4abc5ffc0720d7f92108e22	769,49169-49159-49174-24

rdpClient-JA3.csv hosted with ❤ by GitHub view raw

https://gist.github.com/0x4D31/

Enhanced RDP Security

ᕦ(ò_óˇ)

Windows 10/2019; RDC 10.0.17

JA3: ce5f3254611a8c095a3d821d44539877

Search this file...

os version	rdp client	ja3	ja3Algorithms
Windows XP SP3	RDC 6.1.7600	c8a0d08d2cbee4bed7cd90e47588ab9b	769,4-5-10-9-100-98-3-6-19
Windows 2012	RDC 6.2.9200	bc2874f25a8254edb36147c151527cfa	771,49192-49191-49172-49
Windows 2008r2	RDC 6.3.9600	e6a4e2358d4eee6122403f3cb835bcbd	771,49192-49191-49172-49
Windows 2012r2	RDC 6.3.9600	3e686105164b7c9a4cbd59142f18a4e7	771,49192-49191-49172-49
Windows 7	RDC 6.3.9600	d54b3eb800cbeccf99fd5d5cdcd7b5b5	771,49192-49191-49172-49
Windows 2019	RDC 10.0.17763	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
Windows 10	RDC 10.0.17134	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
macOS	Microsoft Remote Desktop	e4d448cdfe06dc1243c1eb026c74ac9a	771,255-49196-49195-4918
macOS	FreeRDP	75fb48a465416d66291fb52a733d4787	769,49172-49162-57-56-55-
macOS	rdpy, rdesktop, python	e2121ae1544cd5acae048d03505068a6	769,49162-49172-57-49161
macOS	robertdavidgraham/rdpscan	0b3e989a2ad13829ab8d65d132480e41	769,49172-49162-57-56-65
macOS	pupy's rdp module	f330c48fc4abc5ffc0720d7f92108e22	769,49169-49159-49174-24

rdpClient-JA3.csv hosted with ❤ by GitHub view raw

https://gist.github.com/0x4D31/

Enhanced RDP Security

ᕦ(ò_óˇ)

Pupy's RDP module

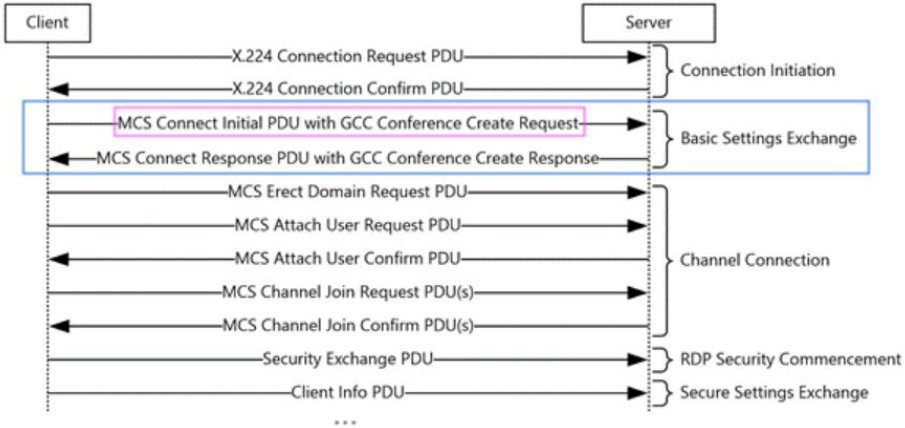
JA3: f330c48fc4abc5ffc0720d7f92108e22

Search this file...

os version	rdp client	ja3	ja3Algorithms
Windows XP SP3	RDC 6.1.7600	c8a0d08d2cbee4bed7cd90e47588ab9b	769,4-5-10-9-100-98-3-6-19
Windows 2012	RDC 6.2.9200	bc2874f25a8254edb36147c151527cfa	771,49192-49191-49172-49
Windows 2008r2	RDC 6.3.9600	e6a4e2358d4eee6122403f3cb835bcbd	771,49192-49191-49172-49
Windows 2012r2	RDC 6.3.9600	3e686105164b7c9a4cbd59142f18a4e7	771,49192-49191-49172-49
Windows 7	RDC 6.3.9600	d54b3eb800cbeccf99fd5d5cdcd7b5b5	771,49192-49191-49172-49
Windows 2016	RDC 10.0.14393	67e3d18fd9dddbbc8eca65f7dedac674	771,49196-49195-49200-49
Windows 2019	RDC 10.0.17763	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
Windows 10	RDC 10.0.17134	ce5f3254611a8c095a3d821d44539877	771,49196-49195-49200-49
macOS	Microsoft Remote Desktop	e4d448cdfe06dc1243c1eb026c74ac9a	771,255-49196-49195-4918
macOS	FreeRDP	75fb48a465416d66291fb52a733d4787	769,49172-49162-57-56-55-
macOS	rdpy, rdesktop, python	e2121ae1544cd5acae048d03505068a6	769,49162-49172-57-49161
macOS	robertdavidgraham/rdpscan	0b3e989a2ad13829ab8d65d132480e41	769,49172-49162-57-56-65
macOS	pupy's rdp module	f330c48fc4abc5ffc0720d7f92108e22	769,49169-49159-49174-24

rdpClient-JA3.csv hosted with ❤ by GitHub view raw

https://gist.github.com/0x4D31/

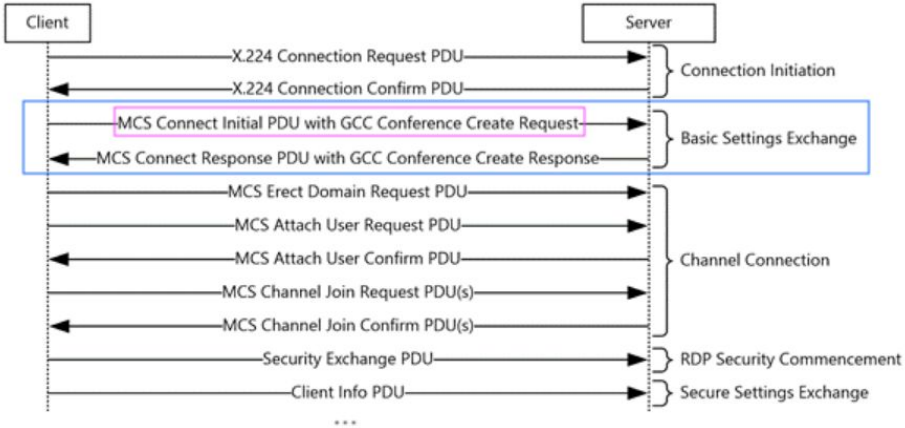


Ref: Microsoft, “Remote Desktop Protocol: Basic Connectivity and Graphics Remoting”

Standard RDP Security

ლ(ﾟ∼°ﾟლ)

NO **TLS** in Standard Mode



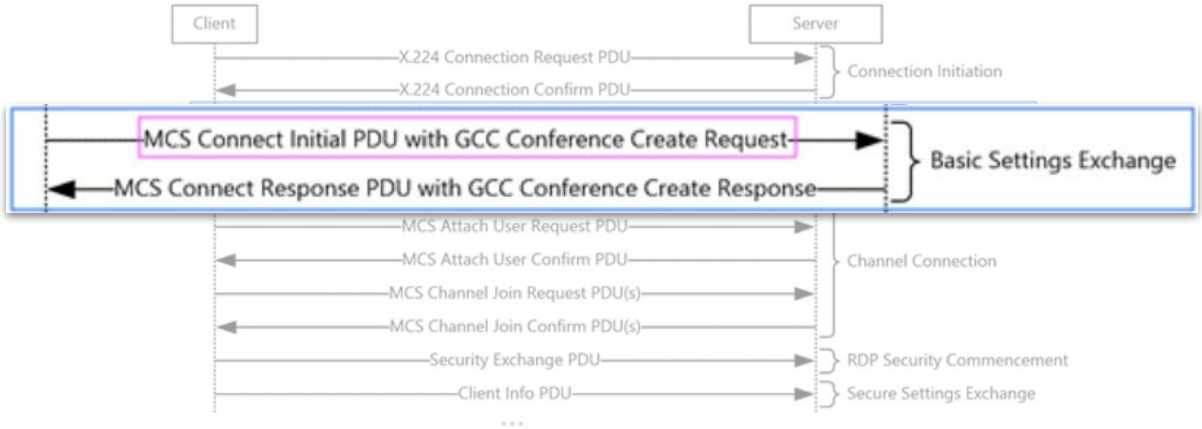
Ref: Microsoft, "Remote Desktop Protocol: Basic Connectivity and Graphics Remoting"

Standard RDP Security

ლ(ﾟ.°~°.ﾟ)ლ

Uses its own encryption mechanism

based on **RSA and RC4/3DES**

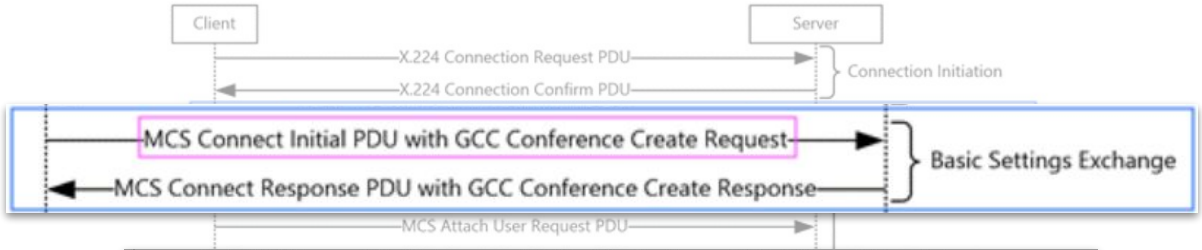


Ref: Microsoft, "Remote Desktop Protocol: Basic Connectivity and Graphics Remoting"

Standard RDP Security

ლ(ⁿ°~°ⁿ)ლ

Interesting fields in the **Basic Settings Exchange** phase

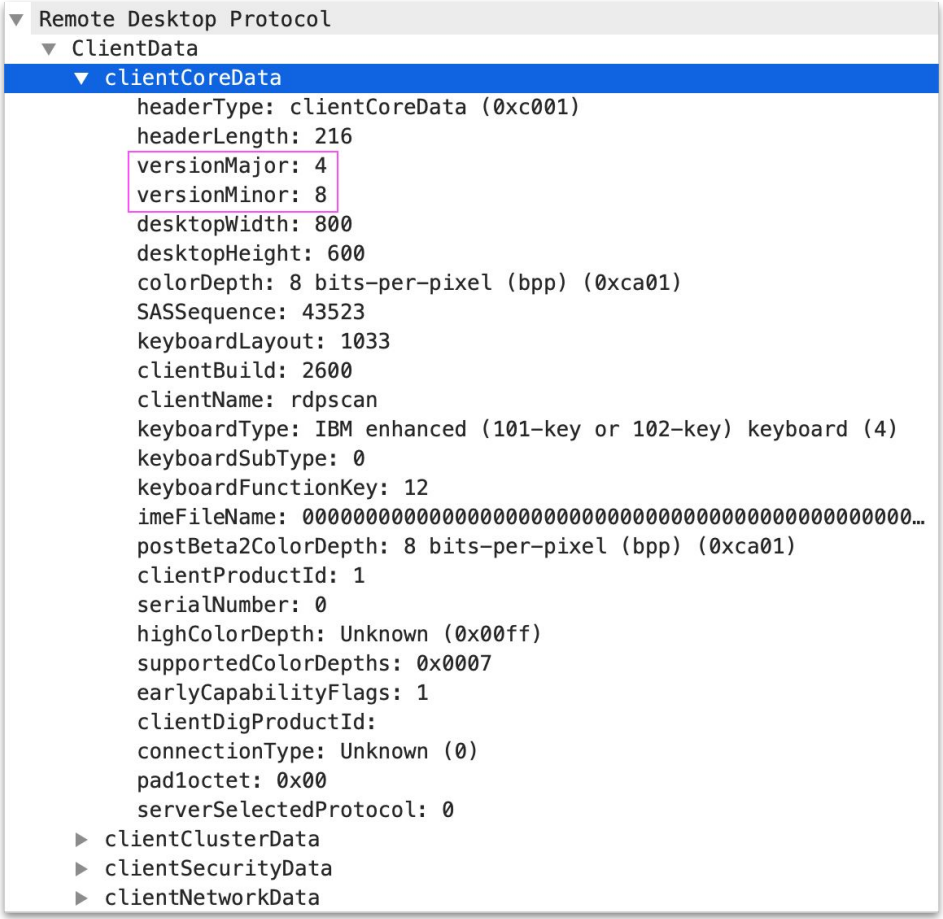



```
    8  0.003577     172.16.1…      39079  172.16.49…    3389  RDP     ClientData
    9  0.003676     172.16.4…       3389  172.16.12…   39079  TCP     3389 → 39079 [ACK] Seq=
   10  0.004104     172.16.4…       3389  172.16.12…   39079  RDP     ServerData Encryption:
   11  0.005352     172.16.1…      39079  172.16.49…    3389  COTP    DT TPDU (0) EOT
▶ Frame 8: 512 bytes on wire (4096 bits), 512 bytes captured (4096 bits)
▶ Ethernet II, Src: Vmware_35:84:c6 (00:50:56:35:84:c6), Dst: Vmware_e6:24:31 (00:50:56:e6:2
▶ Internet Protocol Version 4, Src: 172.16.12.149, Dst: 172.16.49.130
▶ Transmission Control Protocol, Src Port: 39079, Dst Port: 3389, Seq: 44, Ack: 20, Len: 458
▶ TPKT, Version: 3, Length: 458
▶ ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
▶ MULTIPOINT-COMMUNICATION-SERVICE T.125
▶ GENERIC-CONFERENCE-CONTROL T.124
▼ Remote Desktop Protocol
  ▼ ClientData
    ▶ clientCoreData
    ▶ clientClusterData
    ▼ clientSecurityData
        headerType: clientSecurityData (0xc002)
        headerLength: 12
        encryptionMethods: 03000000
        extEncryptionMethods: 00000000
    ▶ clientNetworkData
```

Standard RDP Security

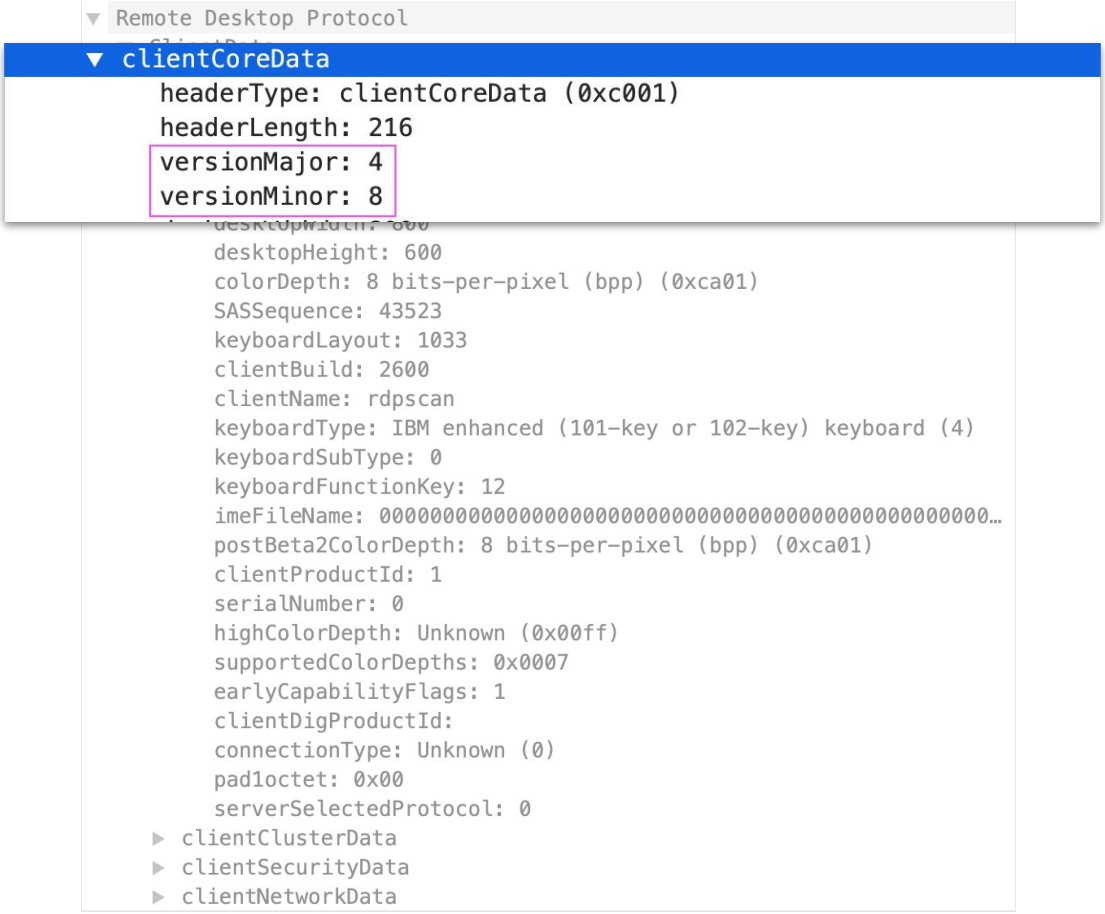
ᘳ(˵°~°˵)ᘴ

Interesting fields in the Basic Settings Exchange phase



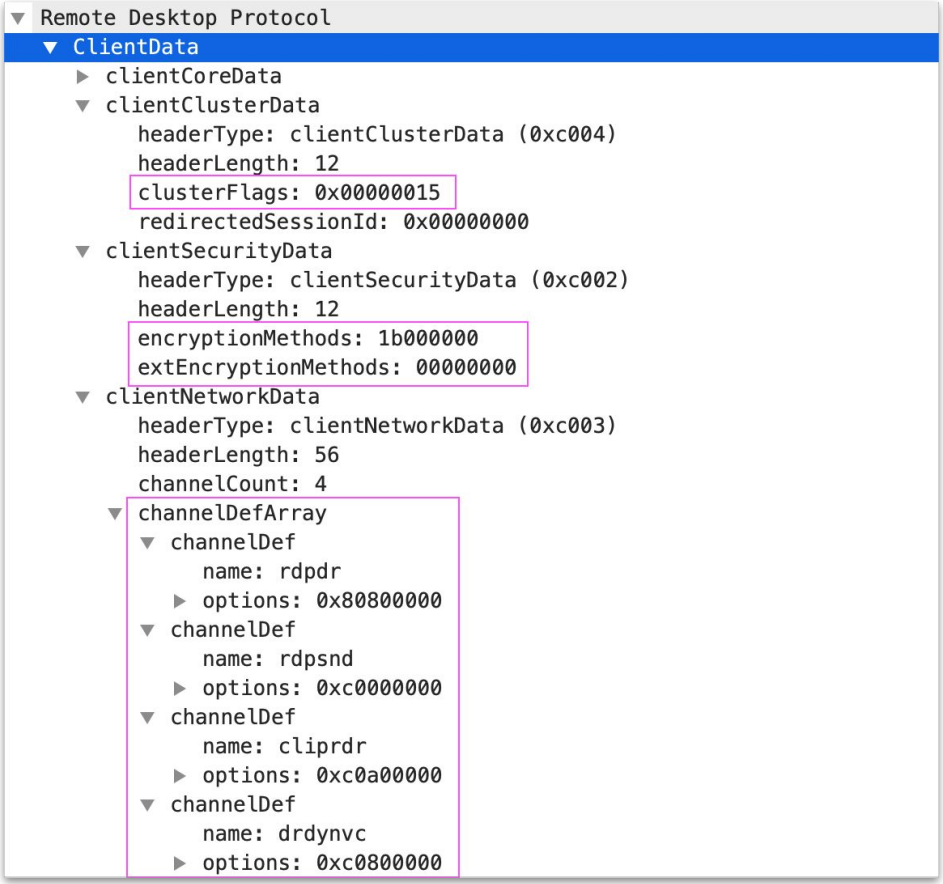
Standard RDP Security

ᕕ(ᐛ°~°ᐛ)ᕗ



Standard RDP Security

ᘛ(˵°~°˵)ᘚ

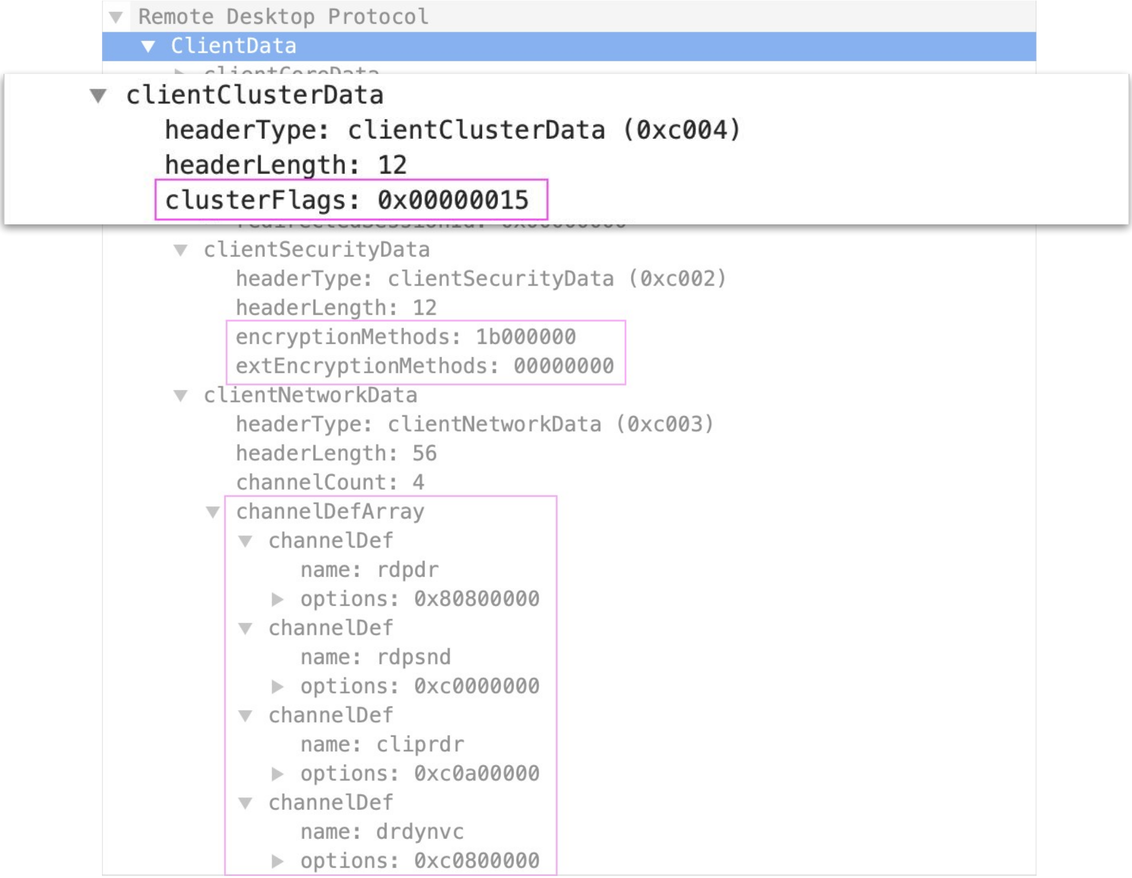


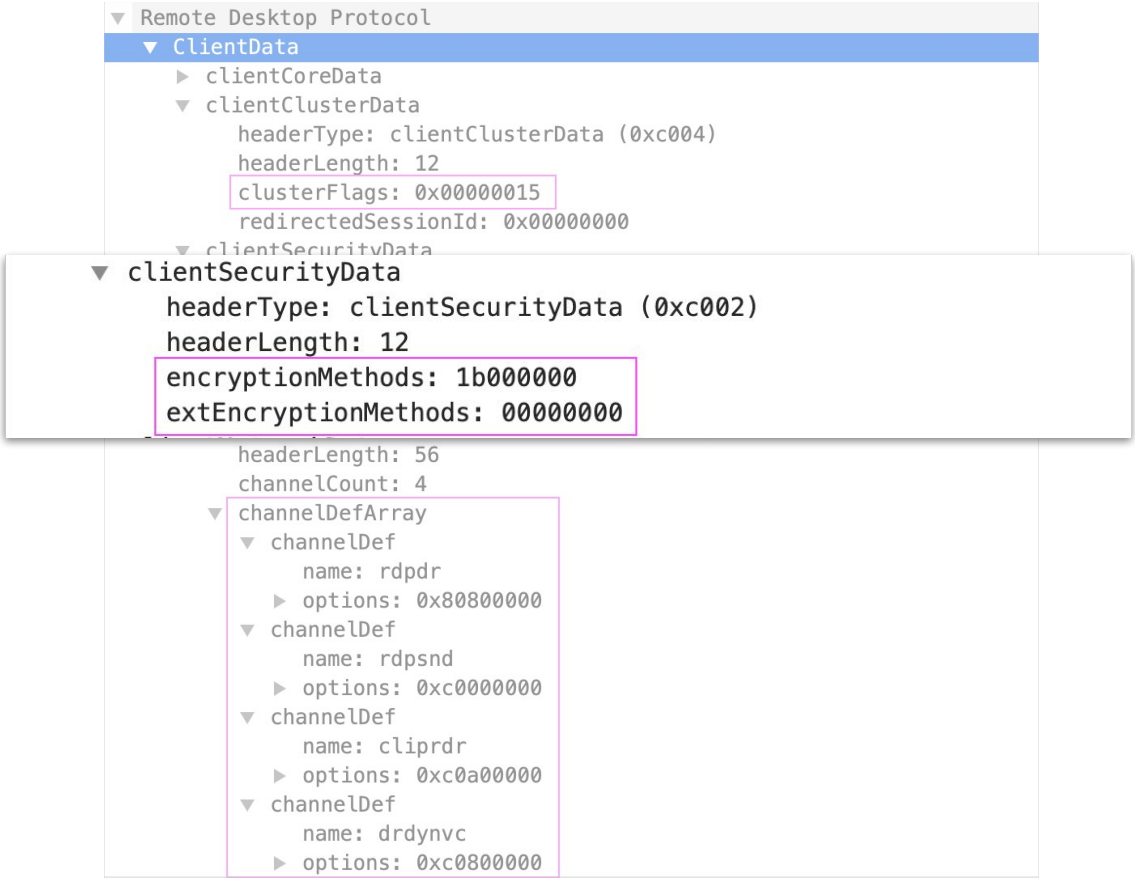
Standard RDP Security

ᘳ(˵°~°˵)ᘰ

Standard RDP Security

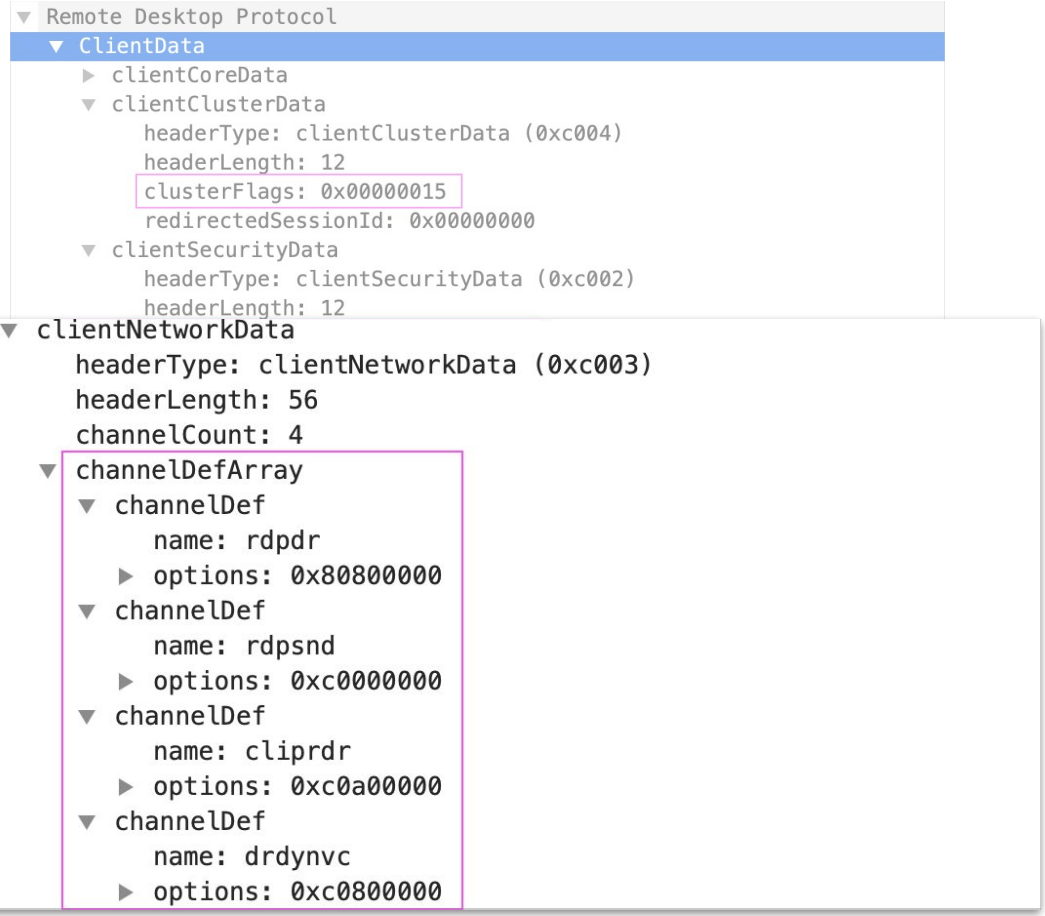
୧(„°~°„)୨





Standard RDP Security

ᕕ(ᐛ°~°ᐛ)ᕗ



Standard RDP Security

ᘳ(˵°~°˵)ᘰ

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

Major Version

10,

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

Minor Version

10,8,

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

Cluster Flags

10,8,00000015,

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

Encryption Methods

10,8,00000015,0000001b,

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

Ext Encryption Methods

10,8,00000015,0000001b,00000000,

Introducing RDFP; profiling RDP clients in standard mode

Concatenate the value of

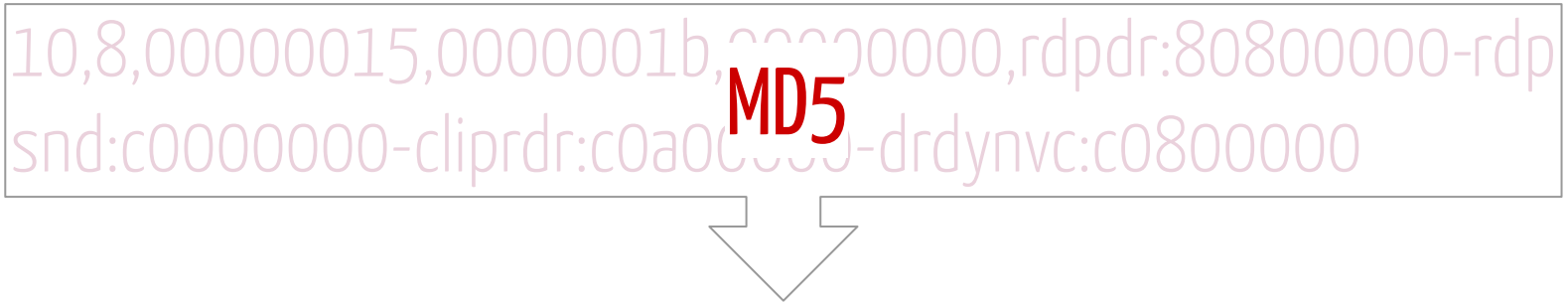
Channel Defs

10,8,00000015,0000001b,00000000,rdpdr:80800000-rdpsnd:c0000000-cliprdr:c0a00000-drdynvc:c0800000

Introducing RDFP; profiling RDP clients in standard mode

10,8,00000015,0000001b,00000000,rdpdr:80800000-rdpsnd:c0000000-cliprdr:c0a00000-drdynvc:c0800000

Introducing RDFP; profiling RDP clients in standard mode

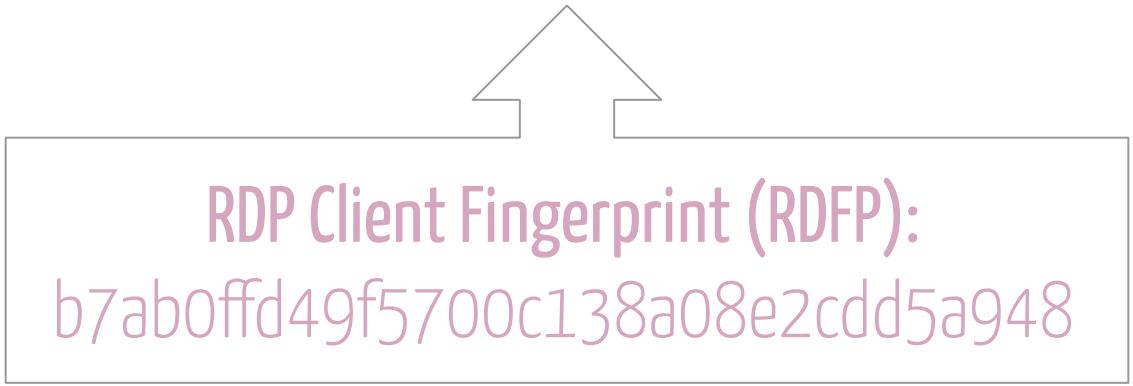


RDP Client Fingerprint (RDFP):

b7ab0ffd49f5700c138a08e2cdd5a948

Introducing RDFP; profiling RDP clients in standard mode

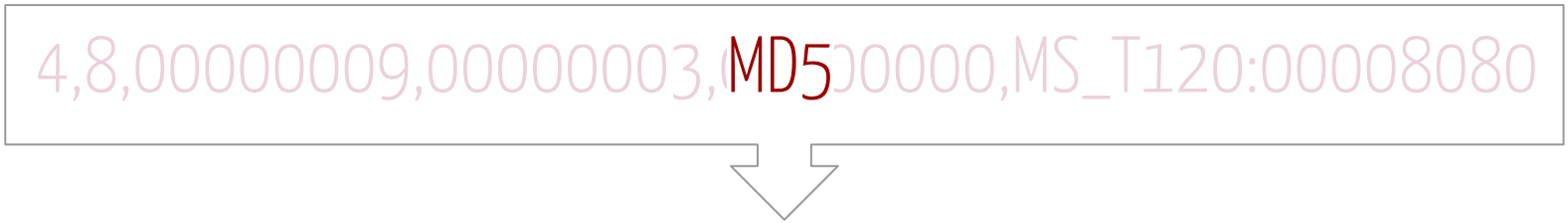
Windows 10, RDC 10.0.17134



Introducing RDFP; profiling RDP clients in standard mode

4,8,00000009,00000003,00000000,MS_T120:00008080

Introducing RDFP; profiling RDP clients in standard mode



RDPSCAN, bluekeep vuln scanner

daeb0f34677984013244 45d3721aa887

RDP Fingerprinting

blog post

medium.com/@0x4d31

```
▼ Remote Desktop Protocol
  ▼ ClientData
    ▼ clientCoreData
        headerType: clientCoreData (0xc001)
        headerLength: 212
        versionMajor: 4
        versionMinor: 8
        desktopWidth: 1280
        desktopHeight: 800
        colorDepth: 8 bits-per-pixel (bpp) (0xca01)
        SASSequence: 43523
        keyboardLayout: 2057
        clientBuild: 2600
        clientName: EMP-LAP-0014
        keyboardType: IBM enhanced (101-key or 102-key) keyboard (4)
        keyboardSubType: 0
        keyboardFunctionKey: 12
        imeFileName: 000000000000000000000000000000000000000000000000…
        postBeta2ColorDepth: 8 bits-per-pixel (bpp) (0xca01)
        clientProductId: 1
        serialNumber: 0
        highColorDepth: 16-bit 565 RGB mask (0x0010)
        supportedColorDepths: 0x0007
        earlyCapabilityFlags: 1
        clientDigProductId: 76487-OEM-0011903-00107
        connectionType: Unknown (0)
        pad1octet: 0x00
    ▶ clientClusterData
    ▼ clientSecurityData
        headerType: clientSecurityData (0xc002)
        headerLength: 12
        encryptionMethods: 01000000
        extEncryptionMethods: 00000000
    ▶ clientNetworkData
```

```
0000  86 51 a4 84 a5 e5 cc e1  7f a8 1b f0 08 00 45 00   ·Q····· ·····E·
0010  01 d0 91 19 40 00 35 06  4c fc c4 34 2b 61 45 37   ····@·5· L··4+aE7
0020  31 46 d5 3e 0d 3d 1c 48  78 9f 99 04 6d 16 80 18   1F·>·=·H x···m···
```

QUICK

https://github.com/0x4D31/quick

a go library based on gopacket for analyzing **QUIC CHLO** messages

```
2019/05/11 05:42:10 192.168.1.9:56149 -> 172.217.167.74:443(htt
Public Flags: d
CID: b8142bd8c89f0e6e
Version: Q043
Packet Number: 1
Message Authentication Hash: 924c2de3a9be804519ffa6e3
Frame Type: a0
Stream ID: 1
Data Length: 1024
Tag: CHLO
Tag Number: 25
SNI: "fonts.googleapis.com"
UAID: "Chrome/74.0.3729.131 Intel Mac OS X 10_14_4"
Tags in Order: ["PAD" "SNI" "STK" "VER" "CCS" "NONC" "AEAD" "UA
Tag Values: map[AEAD:AESG CCRT:86c30bf78fd9372c67f8adc58015e3ff

2019/05/11 05:42:10 192.168.1.9:58556 -> 172.217.25.174:443(htt
Public Flags: d
CID: e4fca1c8ad38dc14
Version: Q043
Packet Number: 1
Message Authentication Hash: 478ed5740d47dccc07b86b43
Frame Type: a0
Stream ID: 1
Data Length: 1024
Tag: CHLO
Tag Number: 25
SNI: "www.youtube.com"
UAID: "Chrome/74.0.3729.131 Intel Mac OS X 10_14_4"
Tags in Order: ["PAD" "SNI" "STK" "VER" "CCS" "NONC" "AEAD" "UA
Tag Values: map[AEAD:AESG CCRT:2237aaad1bebaa6c67f8adc58015e3ff
```

Clustering and Profiling
Internet-Wide Scans

The Problem

- Honeypots: Limited network logging
  - General connection info and application-level data
  - No network metadata and handshake logging!

Network Metadata

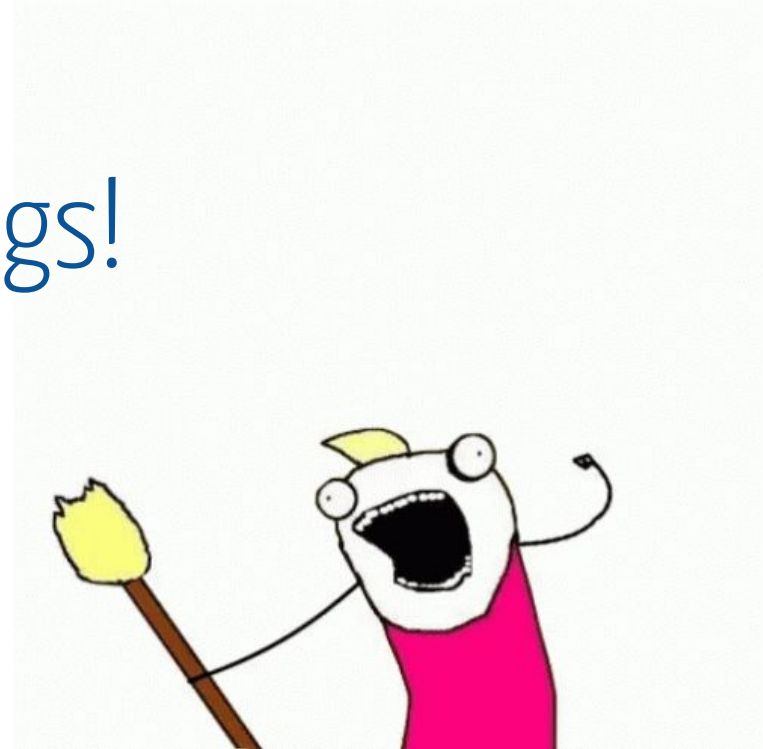
- Bro/Zeek
- Suricata
  - HTTP, DNS, TLS
- Netcap
- Tshark

ssl.log | SSL handshakes

FIELD	TYPE	DESCRIPTION
ts	time	Timestamp when SSL connection d
uid & id		Underlying connection info > See
version	string	SSL version that the server offer
cipher	string	SSL cipher suite that the server c
curve	string	Elliptic curve server chose if using ECDHE
server_name	string	Value of Server Name Indicator SSL ex
session_id	string	Session ID offered by client for session resumption
resumed	bool	Flag that indicates the session was resumed
last_alert	string	Last alert that was seen during the connection
next_protocol	string	Next protocol server chose using application layer next protocol extension, if seen
established	bool	Was this connection established successfully?
cert_chain[1]	vector	Chain of certificates offered by server
cert_chain_fuids[1]	vector	File UIDs for certs in cert_chain
client_cert_chain[1]	vector	Chain of certificates offered by client
client_cert_chain_fuids[1]	vector	File UIDs for certs in client_cert_chain
subject[1]	string	Subject of the X.509 cert offered by server
issuer[1]	string	Subject of the signer of the server cert
client_subject[1]	string	Subject of the X.509 cert offered by client
client_issuer[1]	string	Subject of the signer of the client cert
validation_status[2]	string	Certificate validation result for this handshake
ocsp_status[2]	string	OCSP validation result for this handshake
ocsp_response[2]	string	OCSP response as a string
notary[3]	Cert Notary:: Response	A response from the ICSI certificate notary

fatt.

fingerprint all the things!



66 61 74 74 2e

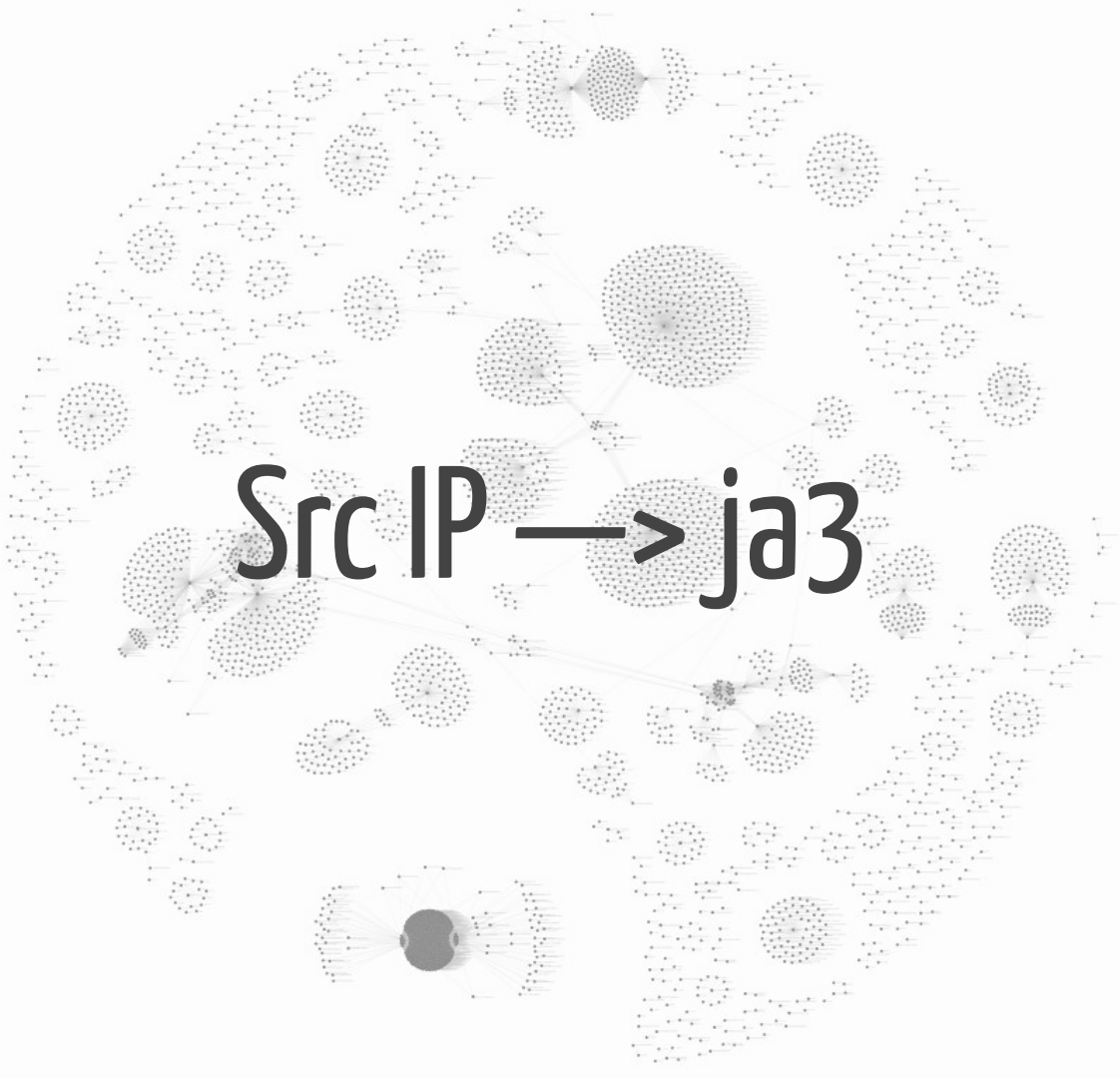
fingerprint all the things!

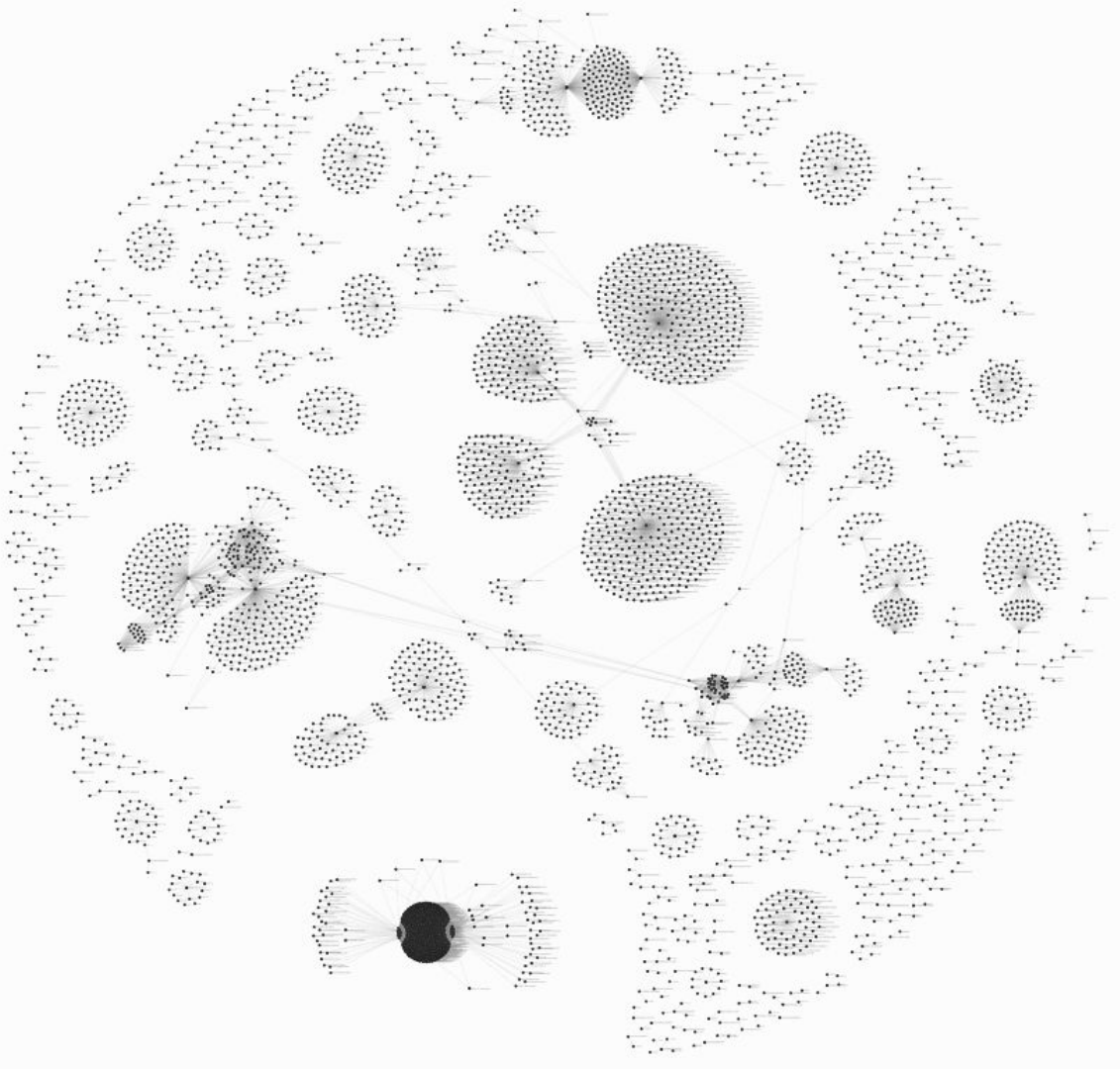
github.com/0x4D31/fatt

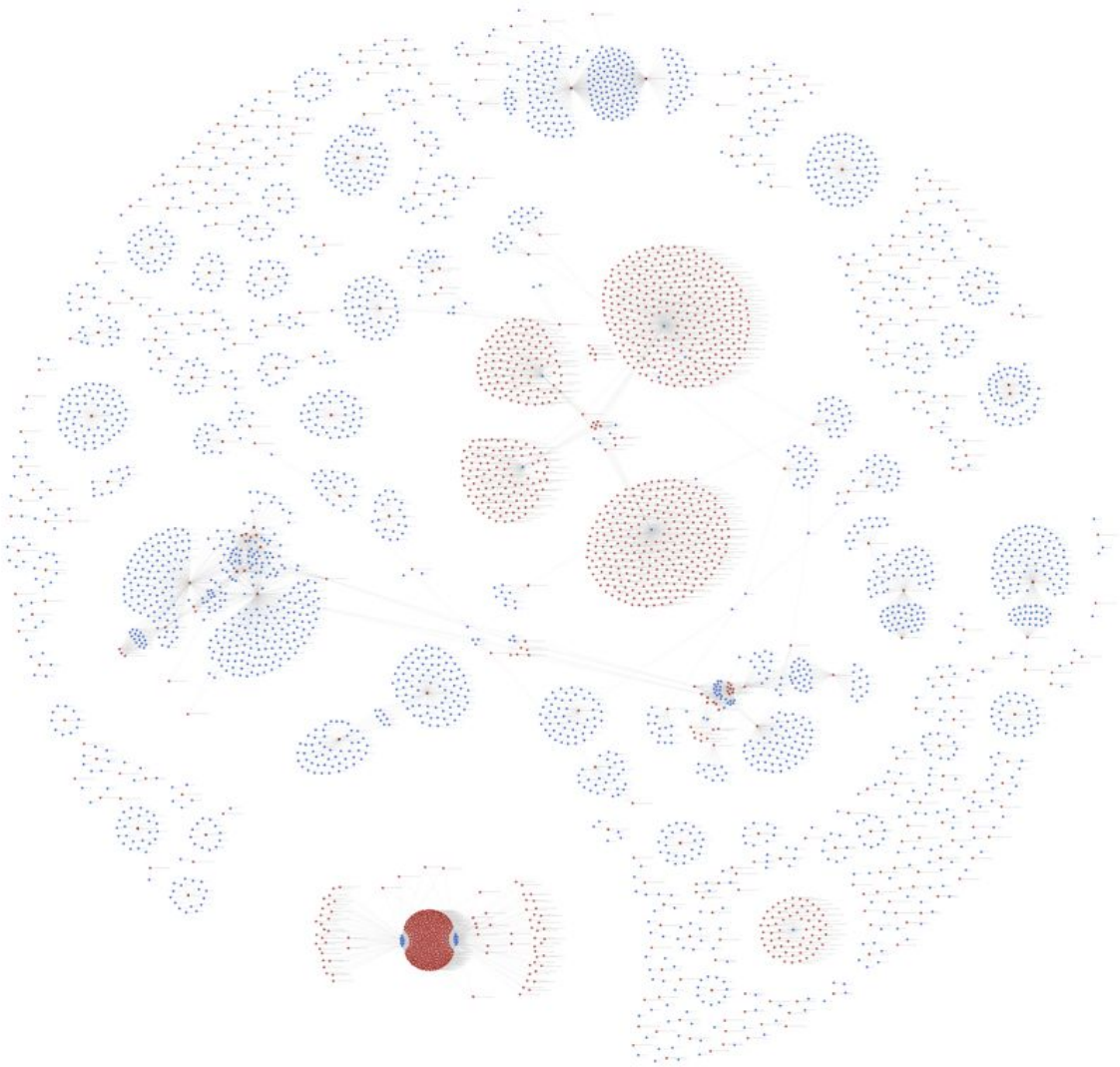
- a pyshark based script for extracting **network metadata** and **fingerprints** from pcap files and live network traffic
- Supported protocols: TLS, SSH, RDP, HTTP, gQUIC
- Main use-case: monitoring honeypots, network forensics
- Json output
- Downside: Performance

Observations

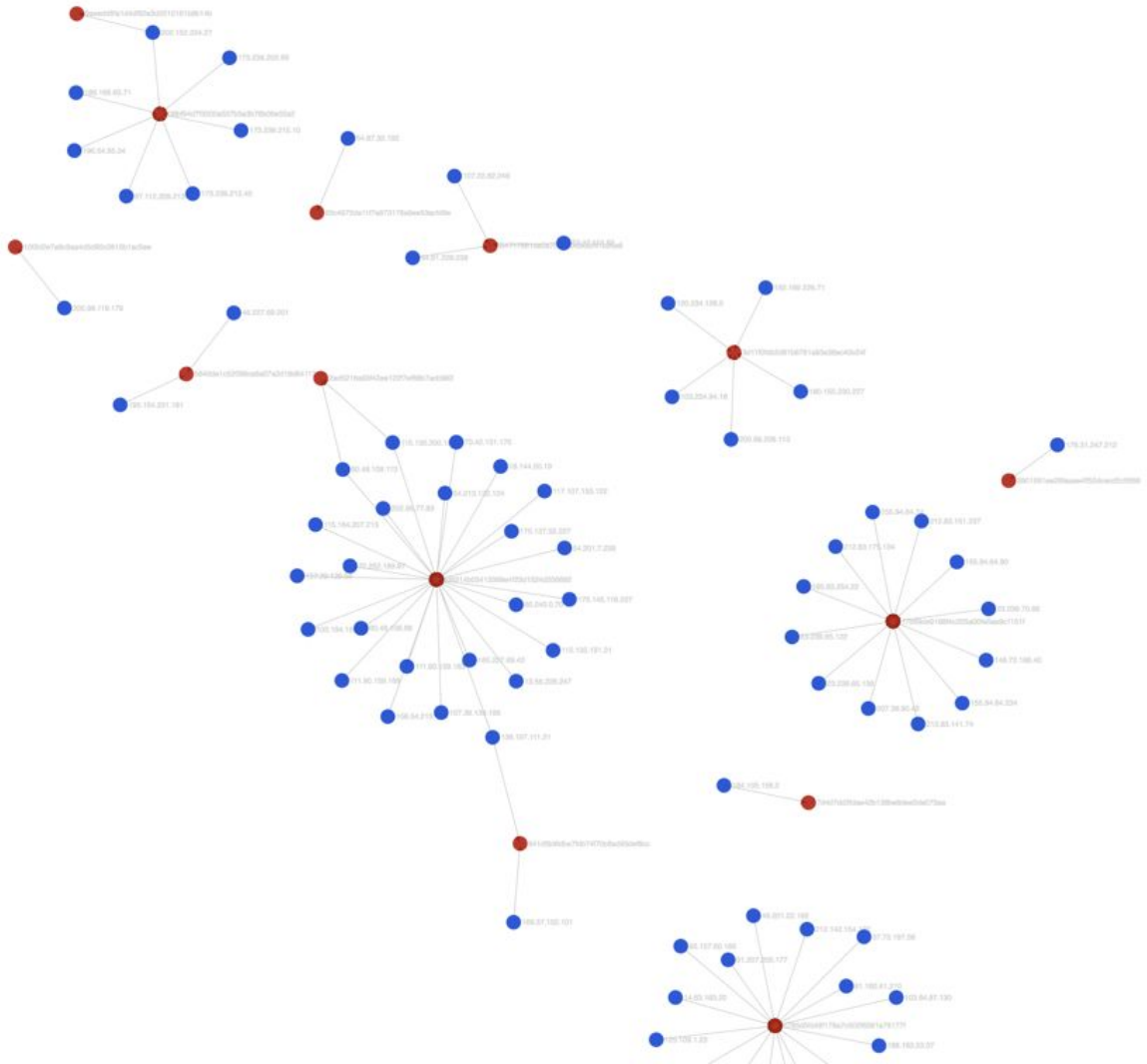
[TLS]


Src IP —> ja3

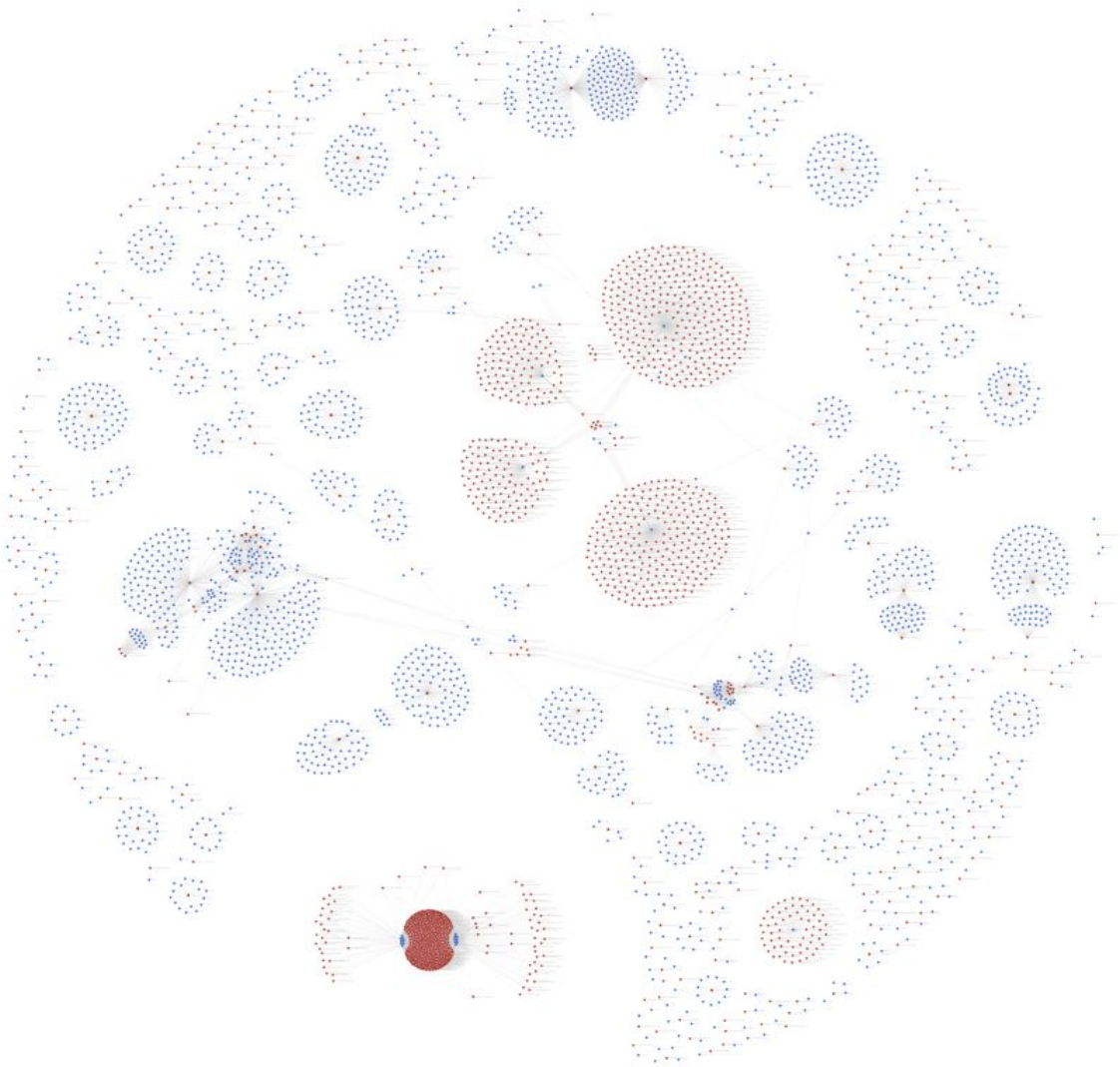




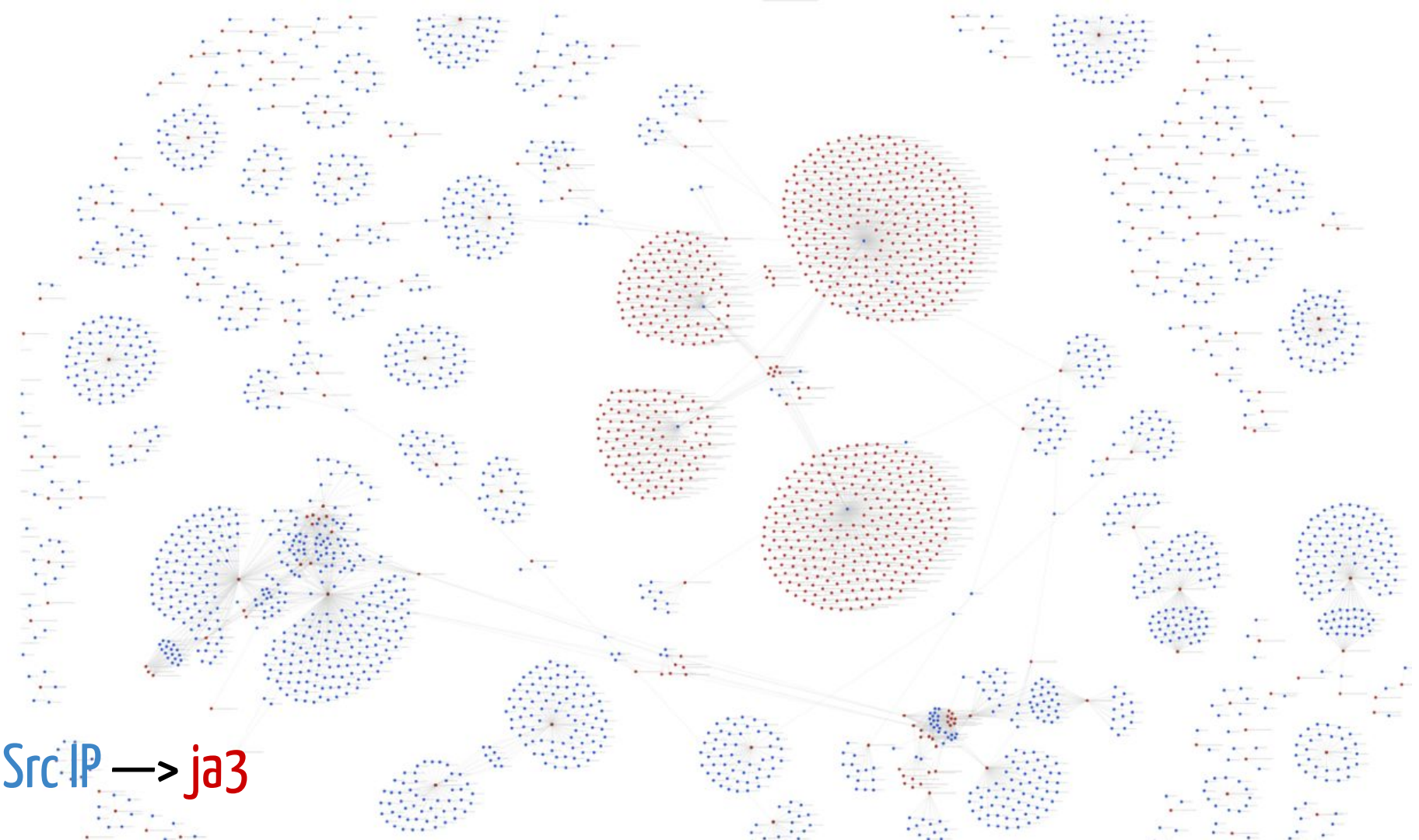
Src IP —> ja3

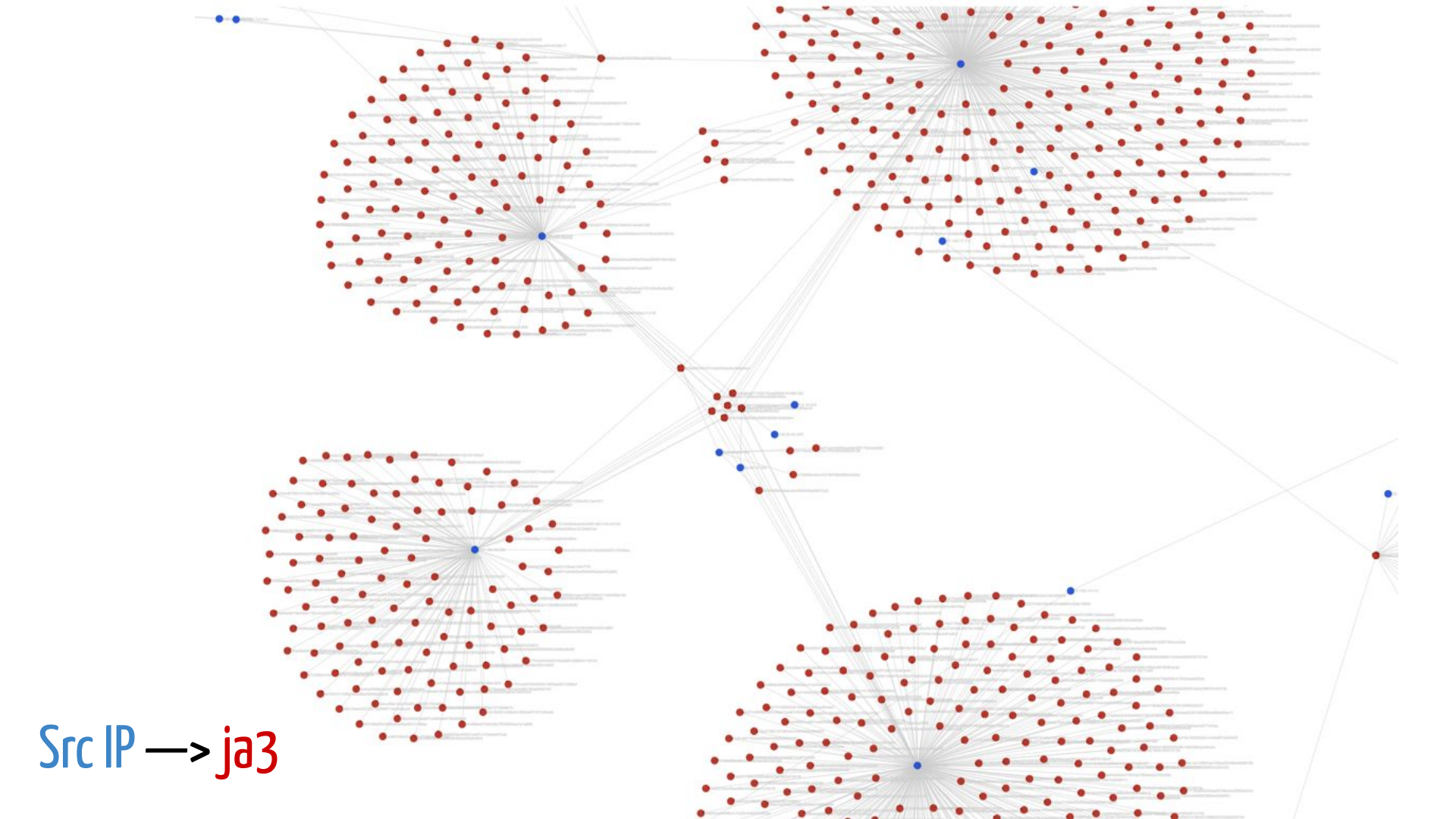


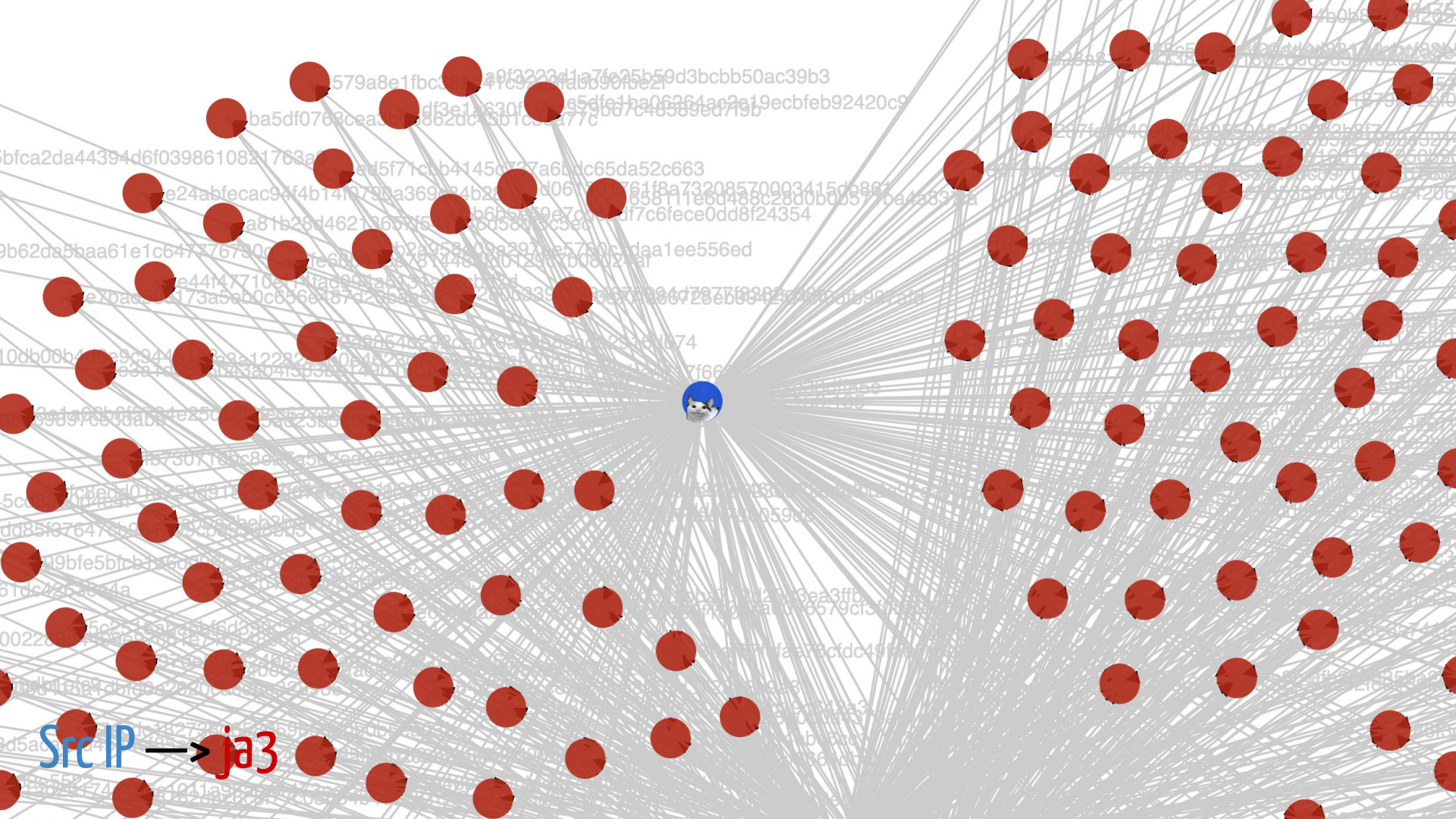
Src IP —> ja3

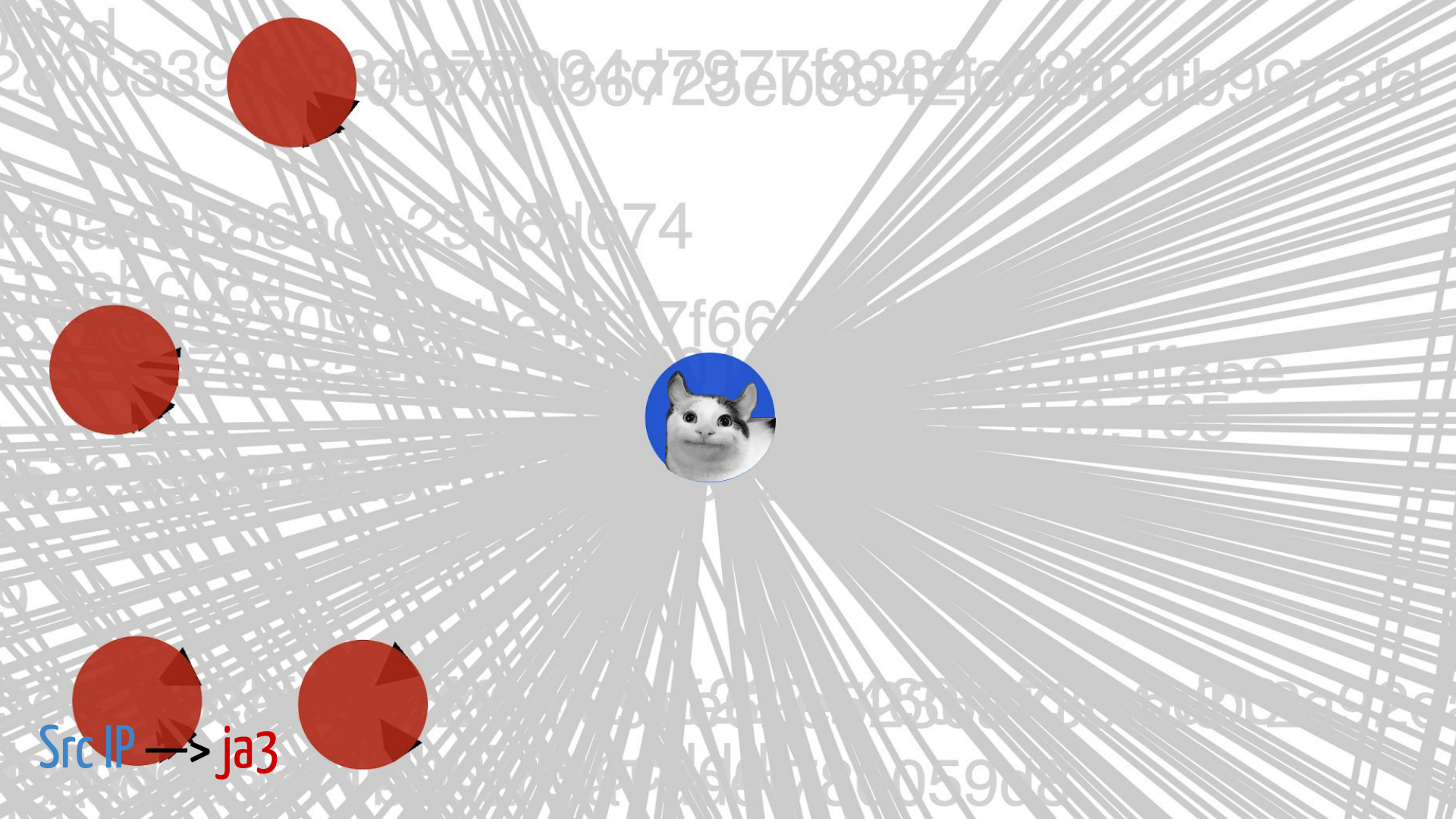


Src IP —> ja3


Src IP —> ja3


Src IP —> ja3


Src IP → ja3


Src IP —> ja3

Src IP —> ja3

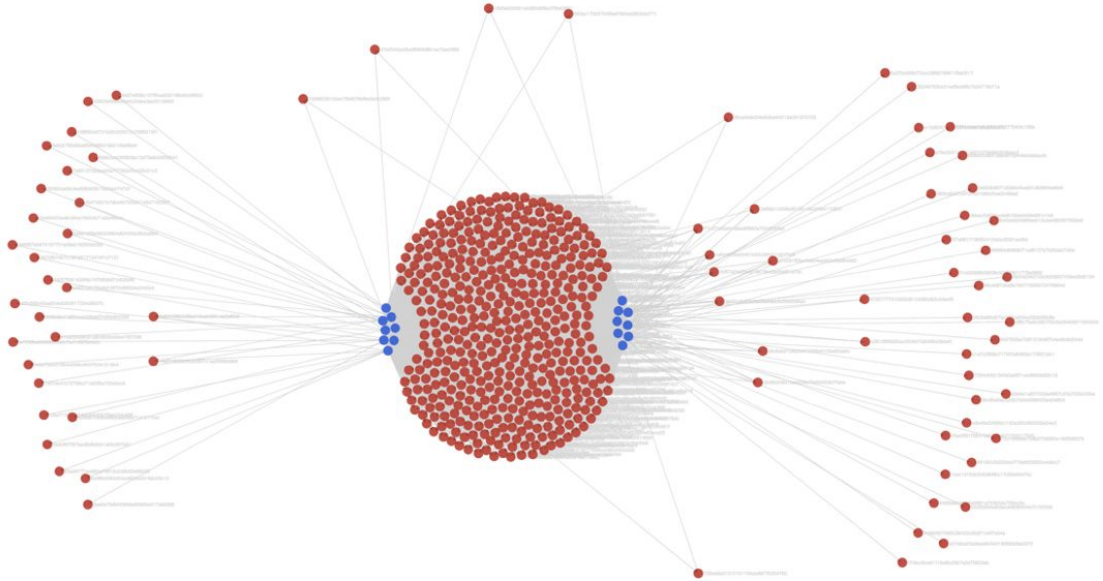
Src IP —> ja3


FOUND IT
imgflip.com

Some attempts to avoid TLS fingerprinting by **randomizing** the **clientHello** fields!

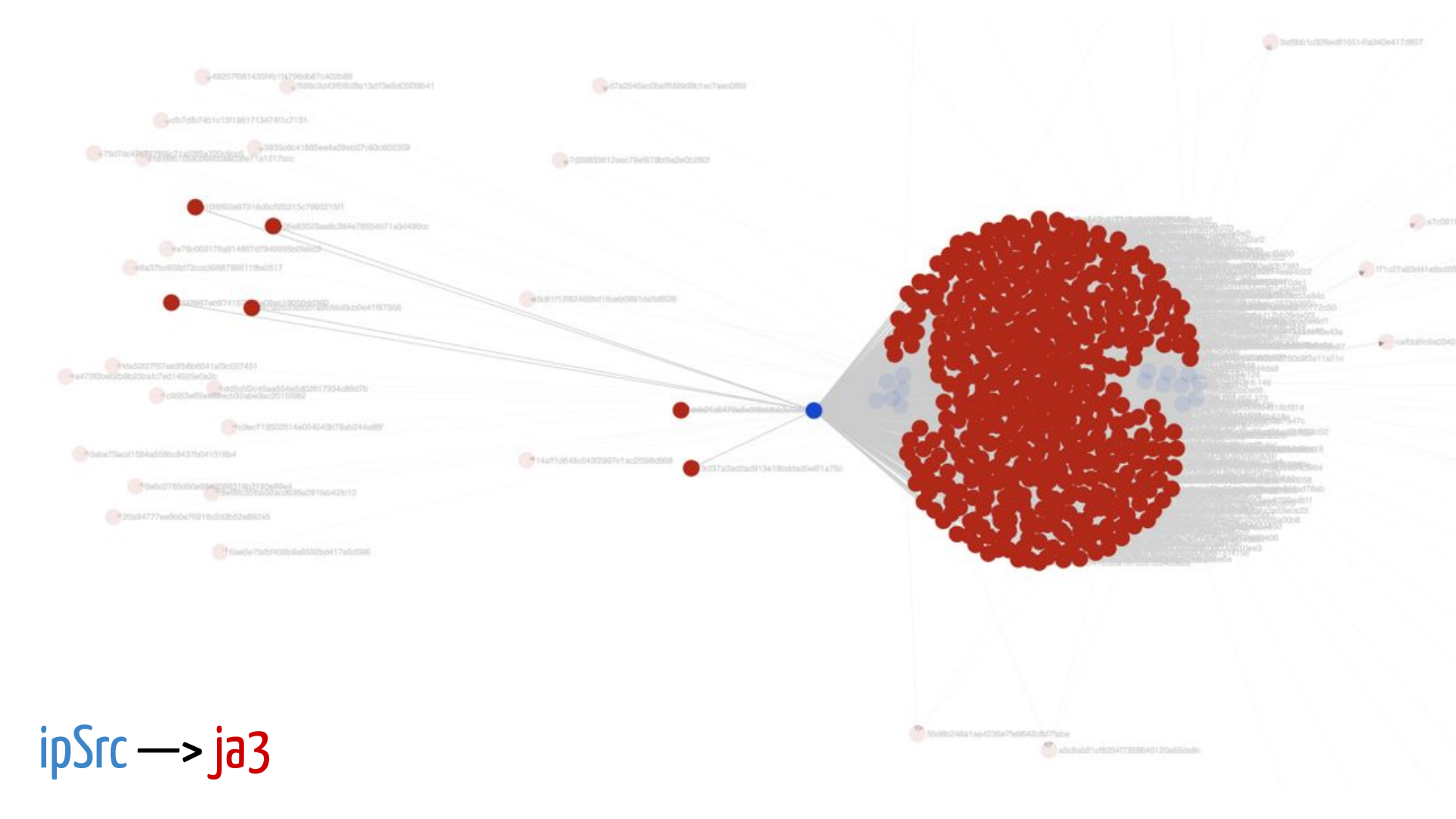
Some attempts to avoid TLS fingerprinting by **randomizing** the **clientHello** fields!

They make themselves easier to detect by attempting to avoid fingerprinting !



one IP address ⟶ many JA3 values

3 different actors, 3 unique patterns



ipSrc —> ja3

Fingerprint Modification /evasion - I

srcip	dstport	ja3_hash	ja3_fields	ja3_str_length	request	tool	org	asn	os
184.185	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
28.185	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
181.53	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
216.146	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
176.220	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
207.173	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
45.103	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
216.146	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
153.71	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode	AS63949	
154.126	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode	AS63949	
180.112	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
172.241	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
132.213	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode	AS63949	
.57	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
237.43	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6	\x15\x03\x03\x00\x02\x01\x00		Linode, LLC	AS63949	Linux 3.11+
253.76	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6		ZMAP_CLIENT	Linode, LLC	AS63949	Linux 3.11+
184.185	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6			Linode, LLC	AS63949	Linux 3.11+
198.123	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6	\x15\x03\x03\x00\x02\x01\x00		Linode, LLC	AS63949	Linux 3.11+
237.43	443	c044e9bc139d7e54aa9ed62568470de1	2,0,,,	6	\x15\x03\x03\x00\x02\x01\x00		Linode, LLC	AS63949	Linux 3.11+
			2,0,,,						
			2,0,,,						

Fingerprint Modification /evasion - I

srcip	dstport	ja3_hash	ja3_fields	ja3_str_length	request	tool	org	asn	os
139.162.184.185	443	dbeecf711df2f2311b34ea8c1afa4ef8	2,131200,,,	11			Linode, LLC	AS63949	Linux 3.11+
178.79.128.185	443	dbeecf711df2f2311b34ea8c1afa4ef8	2,131200,,,	11			Linode, LLC	AS63949	Linux 3.11+
139.162.181.53	443	dbeecf711df2f2311b34ea8c1afa4ef8	2,131200,,,	11			Linode, LLC	AS63949	Linux 3.11+
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Fingerprint Modification /evasion - I

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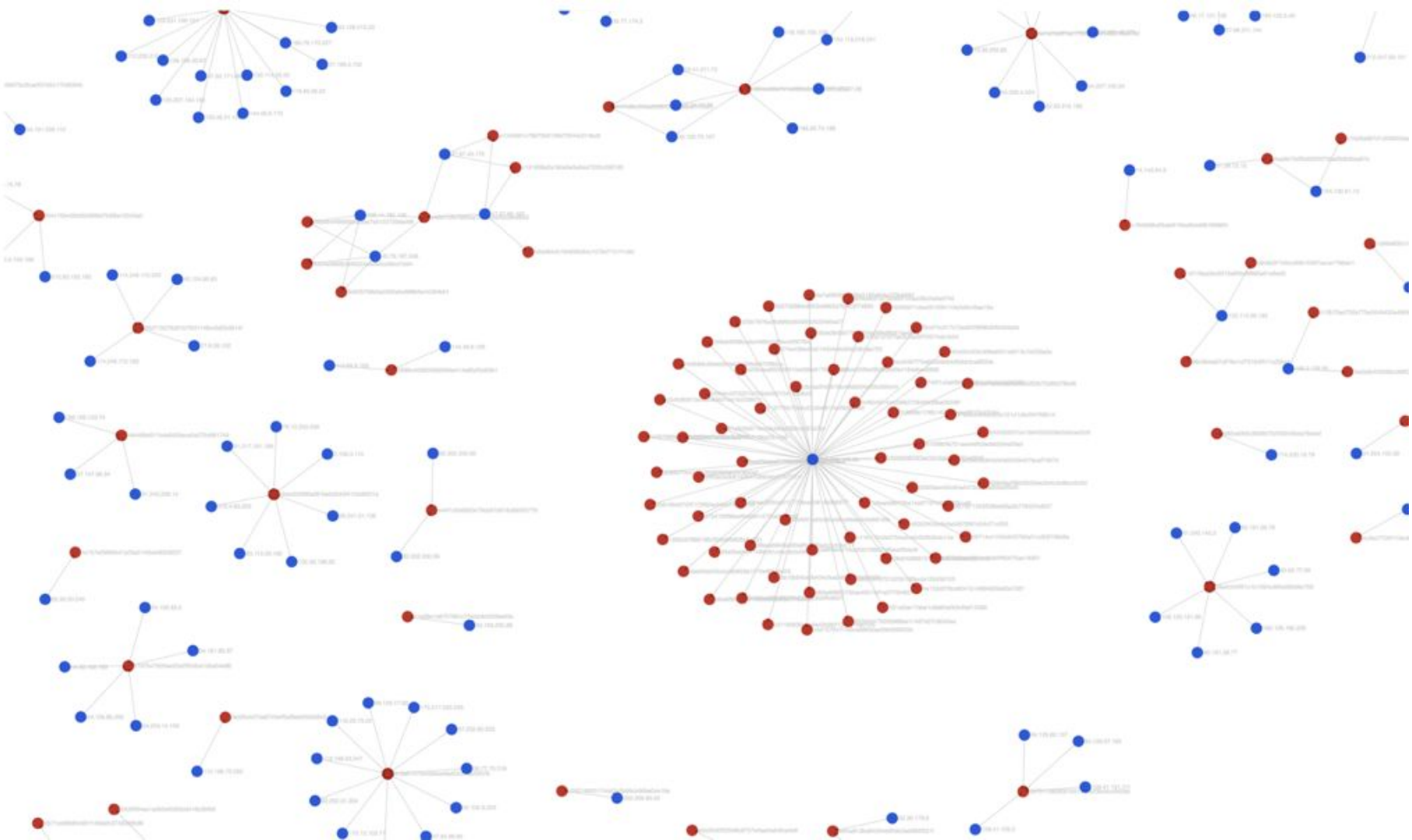

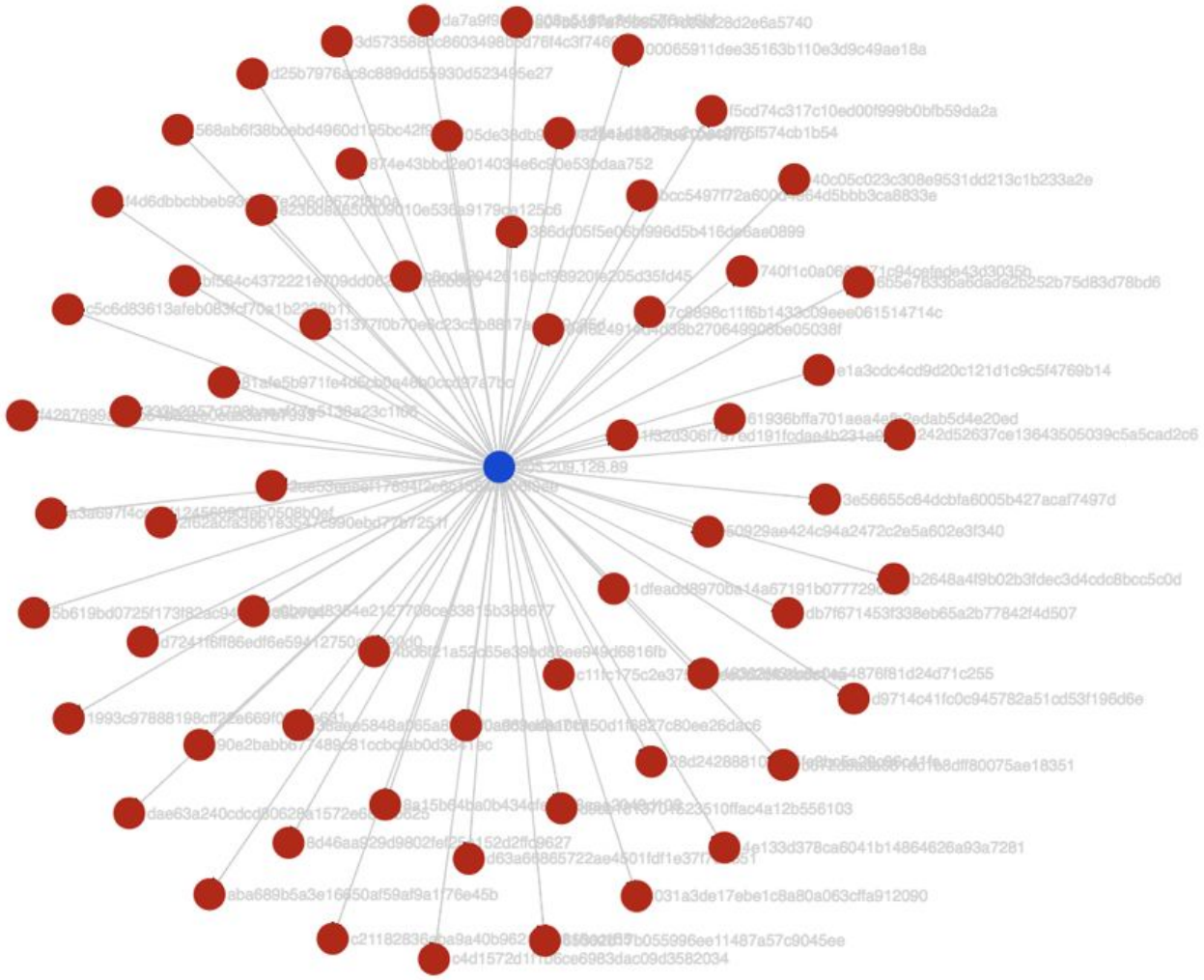

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Fingerprint Modification /evasion - II

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Fingerprint Modification /evasion - II

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103-51

51-103

Fingerprint Modification /evasion - II

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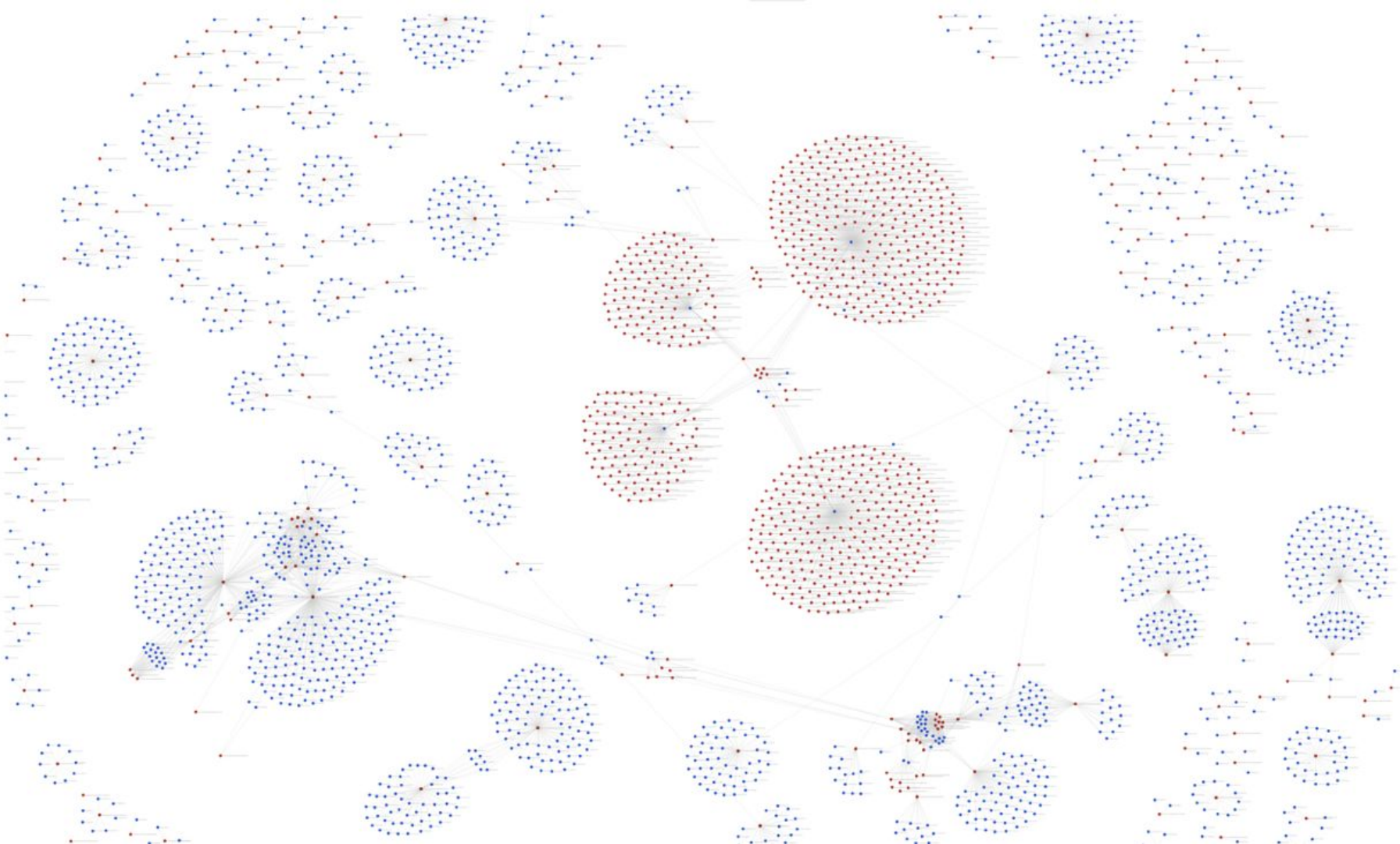

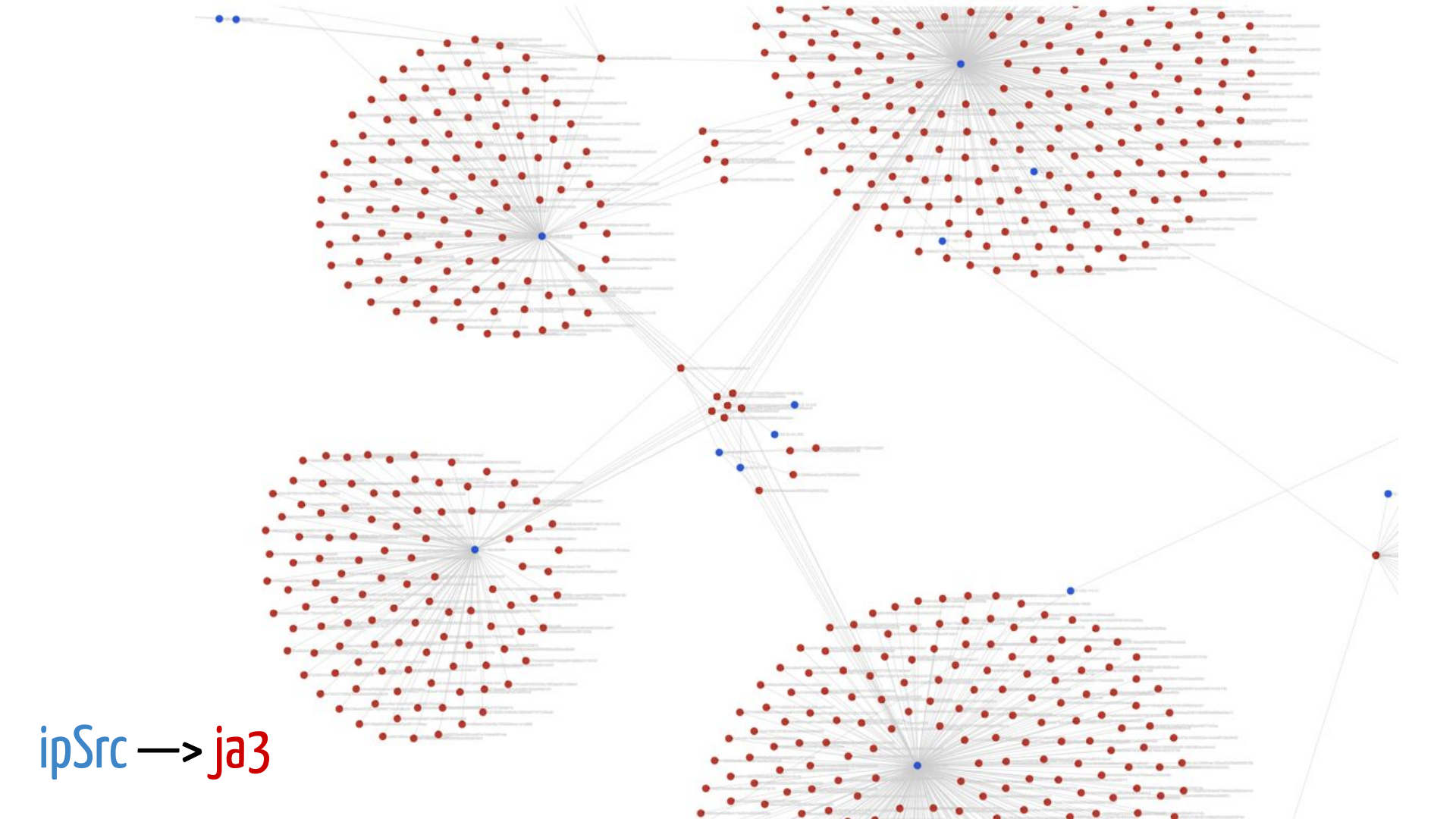
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Fingerprint Modification /evasion - III

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Fingerprint Modification /evasion - III

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2018-01-12T08:09:12.073+0000	.26.237	1482d0297ccd5fdd83c	49173-49317-174-49272-49190-47-42-141-49161-168-108-71-17-49240-75-175-76-187-49293-49296-64-49194-
2018-01-12T08:09:12.118+0000	.26.237	681843facb648b3494c	

Fingerprint Modification /evasion - III

_time	srcip	ja3	ja3_ciphers
2018-01-12T08:09:11.794+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	e76a0619f4cf744ab2b	458944-327808-196736-65664-524416-393280-262272-131200
2018-01-12T08:09:11.842+0000	.26.237	6b2355cd870327854d	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	8d9e064b97093a2c47	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.886+0000	.26.237	a22efd10e07be383b4c	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.934+0000	.26.237	99f66d824338b066f1b	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.978+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:12.026+0000	.26.237	d5ad1a88d4c511586af	0-22016
2018-01-12T08:09:12.072+0000	.26.237	a7674bf7508673e9d0e	148-49283-28-157-49236-49308-12-171-177-5-40-49215-49239-156-49207-69-36-11-54-82-183-27-90-49237-32
2018-01-12T08:09:12.072+0000	.26.237	0443db5df8b9dcc91ae	49176-49214-177-49234-62-67-82-59-49179-50-49158-171-146-65-134-189-143-49252-49194-46-49319-49202-
2018-01-12T08:09:12.072+0000	.26.237	17c9534bfc2a8edeb78	64-49194-75-175-76-187-49293-49296-48-39-181-38-134-49315-159-9-92-170-81-49227-126-55-137-52245-128
2018-01-12T08:09:12.072+0000	.26.237	cff64173dc5b1e96141	49269-183-49316-49202-44-49248-49236-49163-82-49159-49229-144-49257-49185-11-54-12-186-157-67-49292
2018-01-12T08:09:12.072+0000	.26.237	5f68c6edaa625acb28b	55-191-49209-33-170-48-49203-176-49321-49169-190-49314-49182-153-49220-18-195-187-92-137-96-39-4930
2018-01-12T08:09:12.072+0000	.26.237	63fa392b1105a8c4318	189-49205-126-167-49306-49320-49160-37-90-22-49188-134-49223-115-175-49168-63-184-88-49156-49221-49
2018-01-12T08:09:12.072+0000	.26.237	5933eab69b3db48087	180-49306-84-49181-49254-49313-49320-49289-89-49261-184-49284-107-49269-49302-22-103-49249-49305-4
2018-01-12T08:09:12.072+0000	.26.237	c6343c3579d2edea07	137-96-49259-170-163-116-49199-54-49248-49200-49230-172-48-64-49269-75-145-193-70-49163-49290-53-49
2018-01-12T08:09:12.072+0000	.26.237	dd6a913257a568cff93	65279-24-49186-57-161-49218-49162-34-165-140-49-51-49295-49233-56-150-179-98-65278-49208-49179-4915
2018-01-12T08:09:12.072+0000	.26.237	9a1b3fc416b0b64e228	49178-49216-49208-49279-49164-43-49265-92-49266-51-138-52245-19-49270-49307-154-160-49195-121-4919
2018-01-12T08:09:12.073+0000	.26.237	1482d0297ccd5fdd83c	63-30-65278-49153-147-40-49196-49171-61-29-196-79-49242-16-38-49227-49160-57-49315-52-99-49299-1-493
2018-01-12T08:09:12.118+0000	.26.237	681843facb648b3494c	49173-49317-174-49272-49190-47-42-141-49161-168-108-71-17-49240-75-175-76-187-49293-49296-64-49194-

Fingerprint Modification /evasion - III

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2018-01-12T08:09:11.842+0000	.26.237	e76a0619f4cf744ab2b	458944-327808-196736-65664-524416-393280-262272-131200
2018-01-12T08:09:11.842+0000	.26.237	6b2355cd870327854d	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	8d9e064b97093a2c47	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.886+0000	.26.237	a22efd10e07be383b4c	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.934+0000	.26.237	99f66d824338b066f1b	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.978+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:12.026+0000	.26.237	d5ad1a88d4c511586af	0-22016
2018-01-12T08:09:12.072+0000	.26.237	a7674bf7508673e9d0e	148-49283-28-157-49236-49308-12-171-177-5-40-49215-49239-156-49207-69-36-11-54-82-183-27-90-49237-32
2018-01-12T08:09:12.072+0000	.26.237	0443db5df8b9dcc91ae	49176-49214-177-49234-62-67-82-59-49179-50-49158-171-146-65-134-189-143-49252-49194-46-49319-49202-
2018-01-12T08:09:12.072+0000	.26.237	17c9534bfc2a8edeb78	64-49194-75-175-76-187-49293-49296-48-39-181-38-134-49315-159-9-92-170-81-49227-126-55-137-52245-128
2018-01-12T08:09:12.072+0000	.26.237	cff64173dc5b1e96141	49269-183-49316-49202-44-49248-49236-49163-82-49159-49229-144-49257-49185-11-54-12-186-157-67-49292
2018-01-12T08:09:12.072+0000	.26.237	5f68c6edaa625acb28b	55-191-49209-33-170-48-49203-176-49321-49169-190-49314-49182-153-49220-18-195-187-92-137-96-39-4930
2018-01-12T08:09:12.072+0000	.26.237	63fa392b1105a8c4318	189-49205-126-167-49306-49320-49160-37-90-22-49188-134-49223-115-175-49168-63-184-88-49156-49221-49
2018-01-12T08:09:12.072+0000	.26.237	5933eab69b3db48087	180-49306-84-49181-49254-49313-49320-49289-89-49261-184-49284-107-49269-49302-22-103-49249-49305-4
2018-01-12T08:09:12.072+0000	.26.237	c6343c3579d2edea07	137-96-49259-170-163-116-49199-54-49248-49200-49230-172-48-64-49269-75-145-193-70-49163-49290-53-49
2018-01-12T08:09:12.072+0000	.26.237	dd6a913257a568cff93	65279-24-49186-57-161-49218-49162-34-165-140-49-51-49295-49233-56-150-179-98-65278-49208-49179-4915
2018-01-12T08:09:12.072+0000	.26.237	9a1b3fc416b0b64e228	49178-49216-49208-49279-49164-43-49265-92-49266-51-138-52245-19-49270-49307-154-160-49195-121-4919
2018-01-12T08:09:12.073+0000	.26.237	1482d0297ccd5fdd83c	63-30-65278-49153-147-40-49196-49171-61-29-196-79-49242-16-38-49227-49160-57-49315-52-99-49299-1-493
2018-01-12T08:09:12.118+0000	.26.237	681843facb648b3494c	49173-49317-174-49272-49190-47-42-141-49161-168-108-71-17-49240-75-175-76-187-49293-49296-64-49194-

Fingerprint Modification /evasion - III

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2018-01-12T08:09:11.842+0000	.26.237	e76a0619f4cf744ab2b	458944-327808-196736-65664-524416-393280-262272-131200
2018-01-12T08:09:11.842+0000	.26.237	6b2355cd870327854d	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	8d9e064b97093a2c47	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.886+0000	.26.237	a22efd10e07be383b4c	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.934+0000	.26.237	99f66d824338b066f1b	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.978+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:12.026+0000	.26.237	d5ad1a88d4c511586af	0-22016
2018-01-12T08:09:12.072+0000	.26.237	a7674bf7508673e9d0e	148-49283-28-157-49236-49308-12-171-177-5-40-49215-49239-156-49207-69-36-11-54-82-183-27-90-49237-32
2018-01-12T08:09:12.072+0000	.26.237	0443db5df8b9dcc91ae	49176-49214-177-49234-62-67-82-59-49179-50-49158-171-146-65-134-189-143-49252-49194-46-49319-49202-
2018-01-12T08:09:12.072+0000	.26.237	17c9534bfc2a8edeb78	64-49194-75-175-76-187-49293-49296-48-39-181-38-134-49315-159-9-92-170-81-49227-126-55-137-52245-128
2018-01-12T08:09:12.072+0000	.26.237	cff64173dc5b1e96141	49269-183-49316-49202-44-49248-49236-49163-82-49159-49229-144-49257-49185-11-54-12-186-157-67-49292
2018-01-12T08:09:12.072+0000	.26.237	5f68c6edaa625acb28b	55-191-49209-33-170-48-49203-176-49321-49169-190-49314-49182-153-49220-18-195-187-92-137-96-39-4930
2018-01-12T08:09:12.072+0000	.26.237	63fa392b1105a8c4318	189-49205-126-167-49306-49320-49160-37-90-22-49188-134-49223-115-175-49168-63-184-88-49156-49221-49
2018-01-12T08:09:12.072+0000	.26.237	5933eab69b3db48087	180-49306-84-49181-49254-49313-49320-49289-89-49261-184-49284-107-49269-49302-22-103-49249-49305-4
2018-01-12T08:09:12.072+0000	.26.237	c6343c3579d2edea07	137-96-49259-170-163-116-49199-54-49248-49200-49230-172-48-64-49269-75-145-193-70-49163-49290-53-49
2018-01-12T08:09:12.072+0000	.26.237	dd6a913257a568cff93	65279-24-49186-57-161-49218-49162-34-165-140-49-51-49295-49233-56-150-179-98-65278-49208-49179-4915
2018-01-12T08:09:12.072+0000	.26.237	9a1b3fc416b0b64e228	49178-49216-49208-49279-49164-43-49265-92-49266-51-138-52245-19-49270-49307-154-160-49195-121-4919
2018-01-12T08:09:12.073+0000	.26.237	1482d0297ccd5fdd83c	63-30-65278-49153-147-40-49196-49171-61-29-196-79-49242-16-38-49227-49160-57-49315-52-99-49299-1-493
2018-01-12T08:09:12.118+0000	.26.237	681843facb648b3494c	49173-49317-174-49272-49190-47-42-141-49161-168-108-71-17-49240-75-175-76-187-49293-49296-64-49194-

Fingerprint Modification /evasion - III

_time	srcip	ja3	ja3_ciphers
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2018-01-12T08:09:11.842+0000	.26.237	e76a0619f4cf744ab2b	458944-327808-196736-65664-524416-393280-262272-131200
2018-01-12T08:09:11.842+0000	.26.237	6b2355cd870327854d	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	8d9e064b97093a2c47	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.842+0000	.26.237	27a33d6c1e581cf2783	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.886+0000	.26.237	a22efd10e07be383b4c	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.934+0000	.26.237	99f66d824338b066f1b	49199-49195-49200-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-01-12T08:09:11.978+0000	.26.237	27a33d6c1e581cf2783	0-22016
2018-01-12T08:09:12.026+0000	.26.237	d5ad1a88d4c511586af	148-49283-28-157-49236-49308-12-171-177-5-40-49215-49239-156-49207-69-36-11-54-82-183-27-90-49237-32
2018-01-12T08:09:12.072+0000	.26.237	a7674bf7508673e9d0e	49176-49214-177-49234-62-67-82-59-49179-50-49158-171-146-65-134-189-143-49252-49194-46-49319-49202
2018-01-12T08:09:12.072+0000	.26.237	0443db5df8b9dcc91ae	64-49194-75-175-76-187-49293-49296-48-39-181-38-134-49315-159-9-92-170-81-49227-126-55-137-52245-128
2018-01-12T08:09:12.072+0000	.26.237	17c9534bfc2a8edeb78	49269-183-49316-49202-44-49248-49236-49163-82-49159-49229-144-49257-49185-11-54-12-186-157-67-4929
2018-01-12T08:09:12.072+0000	.26.237	cff64173dc5b1e96141	55-191-49209-33-170-48-49203-176-49321-49169-190-49314-49182-153-49220-18-195-187-92-137-96-39-4930
2018-01-12T08:09:12.072+0000	.26.237	5f68c6edaa625acb28b	189-49205-126-167-49306-49320-49160-37-90-22-49188-134-49223-115-175-49168-63-184-88-49156-49221-49
2018-01-12T08:09:12.072+0000	.26.237	63fa392b1105a8c4318	180-49306-84-49181-49254-49313-49320-49289-89-49261-184-49284-107-49269-49302-22-103-49249-49305-4
2018-01-12T08:09:12.072+0000	.26.237	5933eab69b3db48087	137-96-49259-170-163-116-49199-54-49248-49200-49230-172-48-64-49269-75-145-193-70-49163-49290-53-49
2018-01-12T08:09:12.072+0000	.26.237	c6343c3579d2edea07	65279-24-49186-57-161-49218-49162-34-165-140-49-51-49295-49233-56-150-179-98-65278-49208-49179-4915
2018-01-12T08:09:12.072+0000	.26.237	dd6a913257a568cff93	49178-49216-49208-49279-49164-43-49265-92-49266-51-138-52245-19-49270-49307-154-160-49195-121-4919
2018-01-12T08:09:12.072+0000	.26.237	9a1b3fc416b0b64e228	63-30-65278-49153-147-40-49196-49171-61-29-196-79-49242-16-38-49227-49160-57-49315-52-99-49299-1-49
2018-01-12T08:09:12.073+0000	.26.237	1482d0297ccd5fdd83c	49173-49317-174-49272-49190-47-42-141-49161-168-108-71-17-49240-75-175-76-187-49293-49296-64-49194-
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Fingerprint Modification /evasion - III

(~26 days later)

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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.274+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53-
2018-02-09T09:13:30.357+0000	.26.235	e2d87fde34d1ff1f434	40-80-49266-157-49213-49275-81-49200-62-7-49276-124-71-126-165-49183-49185-87-24-49261-147-25-49267-
2018-02-09T09:13:30.357+0000	.26.235	df5779b4f188abc958	79-171-16-92-49277-49168-11-187-49179-99-52243-49292-49290-49192-59-143-37-160-49284-86-24-49181-132
2018-02-09T09:13:30.357+0000	.26.235	a2083923440174e78	72-49160-170-11-49229-197-129-49158-65278-49322-49296-46-49292-49304-114-43-49263-96-125-91-9-49166-
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2018-02-09T09:13:30.357+0000	.26.235	b162bbf7959a7623a	49247-78-49193-52-49256-139-49164-55-135-81-49301-49205-133-49154-190-49244-49294-49170-49278-56-88
2018-02-09T09:13:30.357+0000	.26.235	9c5b4f9c58e53b744	49172-10-83-14-15-158-154-49178-84-49322-49257-49261-49234-144-77-49213-49250-49291-49208-49270-180
2018-02-09T09:13:30.358+0000	.26.235	0fadc51d6aeda5042	49286-21-184-96-44-49249-49214-49274-49189-42-49306-102-49303-39-66-49263-13-49215-194-49271-49164-
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-49155
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Fingerprint Modification /evasion - III

(~26 days later)

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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
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2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.274+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53-
2018-02-09T09:13:30.357+0000	.26.235	e2d87fde34d1ff1f434	40-80-49266-157-49213-49275-81-49200-62-7-49276-124-71-126-165-49183-49185-87-24-49261-147-25-49267-
2018-02-09T09:13:30.357+0000	.26.235	df5779b4f188abc958	79-171-16-92-49277-49168-11-187-49179-99-52243-49292-49290-49192-59-143-37-160-49284-86-24-49181-132
2018-02-09T09:13:30.357+0000	.26.235	a2083923440174e78	72-49160-170-11-49229-197-129-49158-65278-49322-49296-46-49292-49304-114-43-49263-96-125-91-9-49166-
2018-02-09T09:13:30.357+0000	.26.235	aa70fd98d19f6dda13	49310-49251-17-171-49234-49161-71-170-107-49231-49261-49270-49216-74-49269-173-49287-87-49188-4922
2018-02-09T09:13:30.357+0000	.26.235	b162bbf7959a7623a	49247-78-49193-52-49256-139-49164-55-135-81-49301-49205-133-49154-190-49244-49294-49170-49278-56-88
2018-02-09T09:13:30.357+0000	.26.235	9c5b4f9c58e53b744	49172-10-83-14-15-158-154-49178-84-49322-49257-49261-49234-144-77-49213-49250-49291-49208-49270-180
2018-02-09T09:13:30.358+0000	.26.235	0fadc51d6aeda5042	49286-21-184-96-44-49249-49214-49274-49189-42-49306-102-49303-39-66-49263-13-49215-194-49271-49164-
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-49155
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Fingerprint Modification /evasion - III

(~26 days later)

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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.274+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53-
2018-02-09T09:13:30.357+0000	.26.235	e2d87fde34d1ff1f434	40-80-49266-157-49213-49275-81-49200-62-7-49276-124-71-126-165-49183-49185-87-24-49261-147-25-49267-
2018-02-09T09:13:30.357+0000	.26.235	df5779b4f188abc958	79-171-16-92-49277-49168-11-187-49179-99-52243-49292-49290-49192-59-143-37-160-49284-86-24-49181-132
2018-02-09T09:13:30.357+0000	.26.235	a2083923440174e78	72-49160-170-11-49229-197-129-49158-65278-49322-49296-46-49292-49304-114-43-49263-96-125-91-9-49166-
2018-02-09T09:13:30.357+0000	.26.235	aa70fd98d19f6dda13	49310-49251-17-171-49234-49161-71-170-107-49231-49261-49270-49216-74-49269-173-49287-87-49188-4922
2018-02-09T09:13:30.357+0000	.26.235	b162bbf7959a7623a	49247-78-49193-52-49256-139-49164-55-135-81-49301-49205-133-49154-190-49244-49294-49170-49278-56-88
2018-02-09T09:13:30.357+0000	.26.235	9c5b4f9c58e53b744	49172-10-83-14-15-158-154-49178-84-49322-49257-49261-49234-144-77-49213-49250-49291-49208-49270-180
2018-02-09T09:13:30.358+0000	.26.235	0fadc51d6aeda5042	49286-21-184-96-44-49249-49214-49274-49189-42-49306-102-49303-39-66-49263-13-49215-194-49271-49164-
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-49155
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Fingerprint Modification /evasion - III

(~26 days later)

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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.274+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53-
2018-02-09T09:13:30.357+0000	.26.235	e2d87fde34d1ff1f434	40-80-49266-157-49213-49275-81-49200-62-7-49276-124-71-126-165-49183-49185-87-24-49261-147-25-49267-
2018-02-09T09:13:30.357+0000	.26.235	df5779b4f188abc958	79-171-16-92-49277-49168-11-187-49179-99-52243-49292-49290-49192-59-143-37-160-49284-86-24-49181-132
2018-02-09T09:13:30.357+0000	.26.235	a2083923440174e78	72-49160-170-11-49229-197-129-49158-65278-49322-49296-46-49292-49304-114-43-49263-96-125-91-9-49166-
2018-02-09T09:13:30.357+0000	.26.235	aa70fd98d19f6dda13	49310-49251-17-171-49234-49161-71-170-107-49231-49261-49270-49216-74-49269-173-49287-87-49188-4922
2018-02-09T09:13:30.357+0000	.26.235	b162bbf7959a7623a	49247-78-49193-52-49256-139-49164-55-135-81-49301-49205-133-49154-190-49244-49294-49170-49278-56-88
2018-02-09T09:13:30.357+0000	.26.235	9c5b4f9c58e53b744	49172-10-83-14-15-158-154-49178-84-49322-49257-49261-49234-144-77-49213-49250-49291-49208-49270-180
2018-02-09T09:13:30.358+0000	.26.235	0fadc51d6aeda5042	49286-21-184-96-44-49249-49214-49274-49189-42-49306-102-49303-39-66-49263-13-49215-194-49271-49164-
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-49155
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Fingerprint Modification /evasion - III

(~26 days later)

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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.274+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53-
2018-02-09T09:13:30.357+0000	.26.235	e2d87fde34d1ff1f434	40-80-49266-157-49213-49275-81-49200-62-7-49276-124-71-126-165-49183-49185-87-24-49261-147-25-49267-
2018-02-09T09:13:30.357+0000	.26.235	df5779b4f188abc958	79-171-16-92-49277-49168-11-187-49179-99-52243-49292-49290-49192-59-143-37-160-49284-86-24-49181-132
2018-02-09T09:13:30.357+0000	.26.235	a2083923440174e78	72-49160-170-11-49229-197-129-49158-65278-49322-49296-46-49292-49304-114-43-49263-96-125-91-9-49166-
2018-02-09T09:13:30.357+0000	.26.235	aa70fd98d19f6dda13	49310-49251-17-171-49234-49161-71-170-107-49231-49261-49270-49216-74-49269-173-49287-87-49188-4922
2018-02-09T09:13:30.357+0000	.26.235	b162bbf7959a7623a	49247-78-49193-52-49256-139-49164-55-135-81-49301-49205-133-49154-190-49244-49294-49170-49278-56-88
2018-02-09T09:13:30.357+0000	.26.235	9c5b4f9c58e53b744	49172-10-83-14-15-158-154-49178-84-49322-49257-49261-49234-144-77-49213-49250-49291-49208-49270-180
2018-02-09T09:13:30.358+0000	.26.235	0fadc51d6aeda5042	49286-21-184-96-44-49249-49214-49274-49189-42-49306-102-49303-39-66-49263-13-49215-194-49271-49164-
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-49155
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Fingerprint Modification /evasion - III

(~26 days later)

_time	srcip	ja3	ja3_ciphers
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2018-01-15T12:19:22.898+0000	.26.232	23558e64d3f12b140	5-4-2-1-22-51-57-58-24-53-10-27-47-52-49168-49158-49173-49163-49153-59-49200-49196-49192-49188-49172-
2018-02-09T09:13:30.102+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	e76a0619f4cf744ab2	458944-327808-196736-65664-524416-393280-262272-131200
2018-02-09T09:13:30.146+0000	.26.235	b8aee29e75d6428de	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	02c79708912f096059	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.146+0000	.26.235	6231f3e090902b283	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.186+0000	.26.235	225febc6a5c122e4c2	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
2018-02-09T09:13:30.230+0000	.26.235	d4cfea6a0a57b3f8ed	52392-52393-49199-49200-49195-49196-49171-49161-49172-49162-156-157-47-53-49170-10
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2018-02-09T09:13:30.318+0000	.26.235	33d99dd27735072ba	0-22016
2018-02-09T09:13:30.357+0000	.26.235	744d459ee33c957b4	49227-49201-33-183-96-19-49232-80-49175-156-3-49273-179-49199-49264-49304-49215-149-65279-182-57-53
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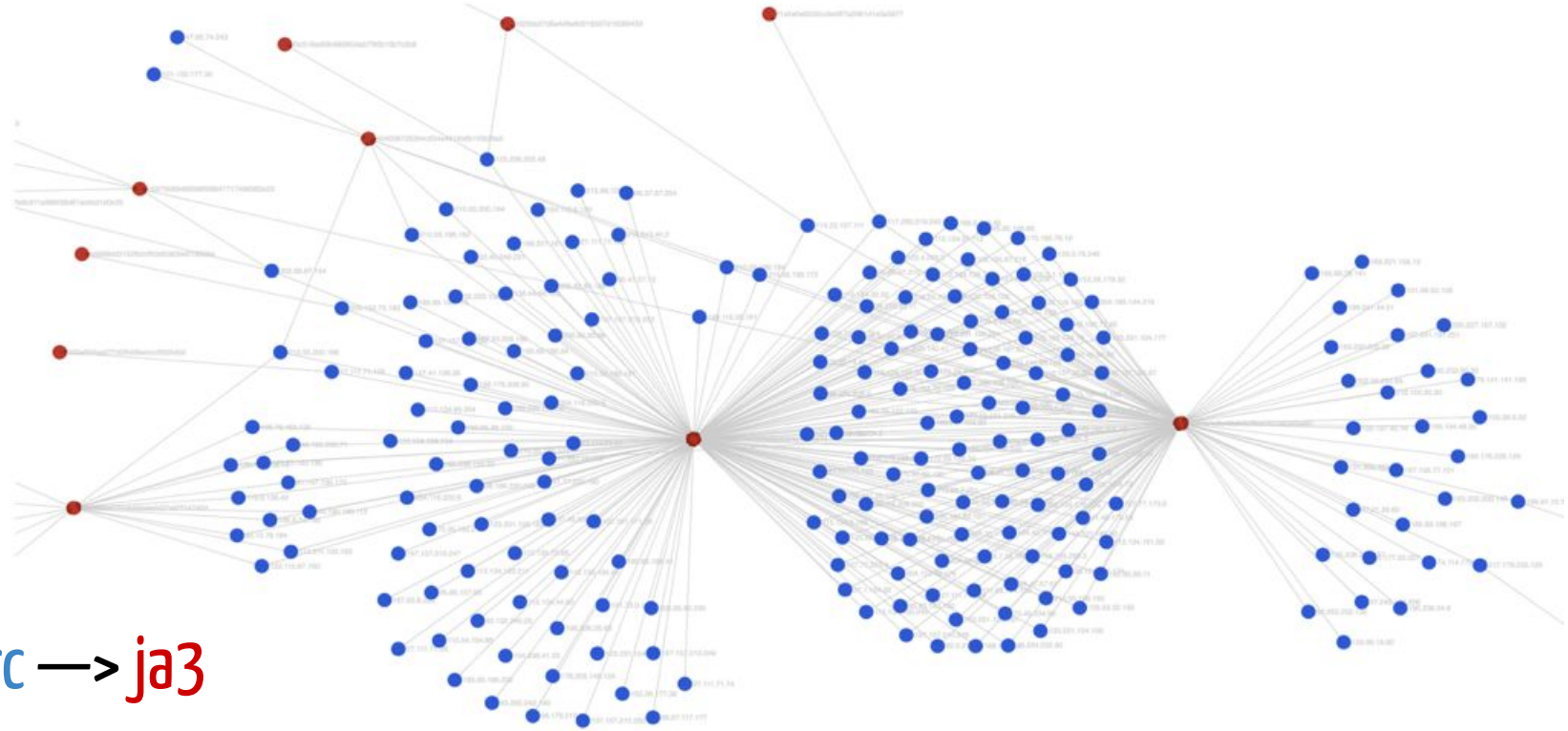
2018-02-09T09:13:30.358+0000	.26.235	0c8df396426c3d053(	49174-49226-49268-78-162-140-22-49225-79-49250-161-38-49206-49214-66-49257-6-4-17-88-49251-180-4915
2018-02-09T09:13:30.358+0000	.26.235	542085678730261d9	168-49200-26-106-49323-49176-49212-49307-100-120-49182-49301-49240-49289-49201-78-49218-148-49302-

Profiling the tools and actors



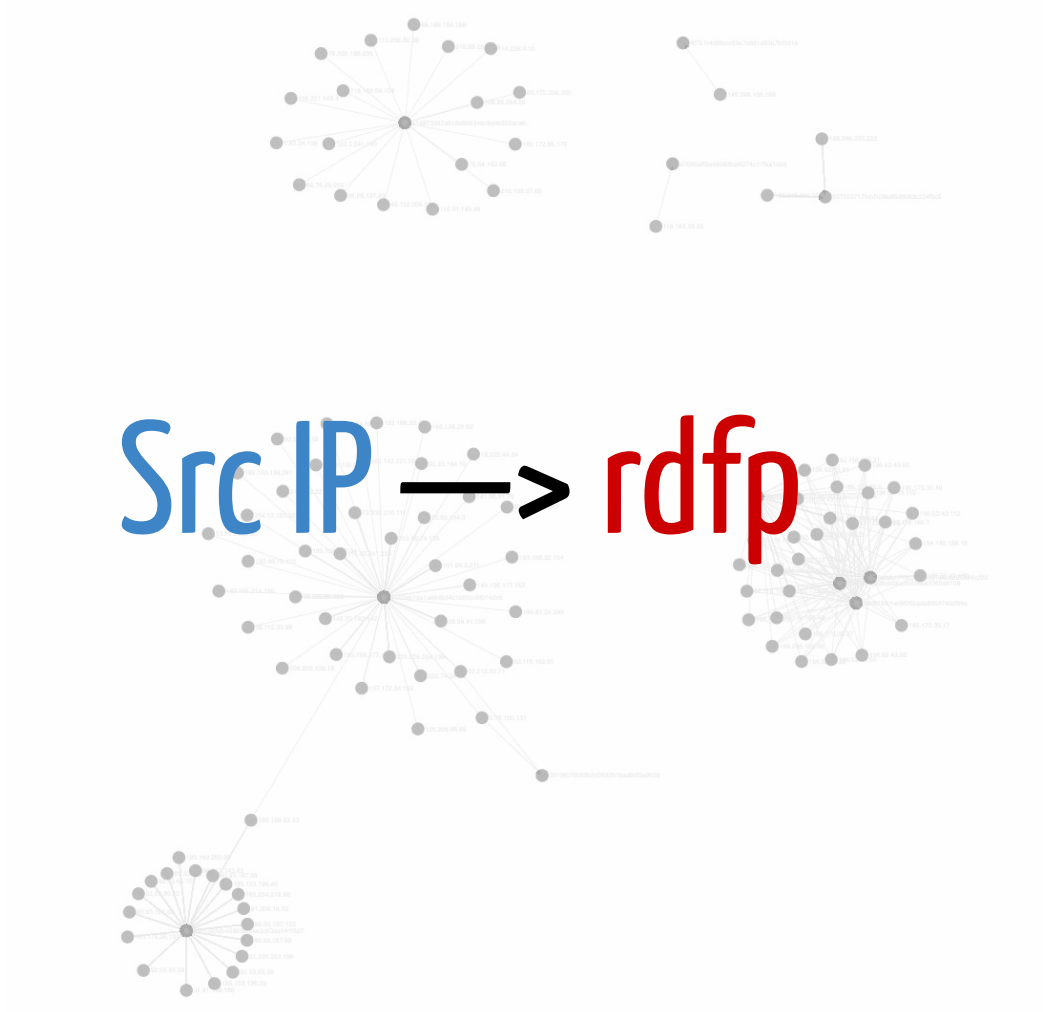
ipSrc —> ja3

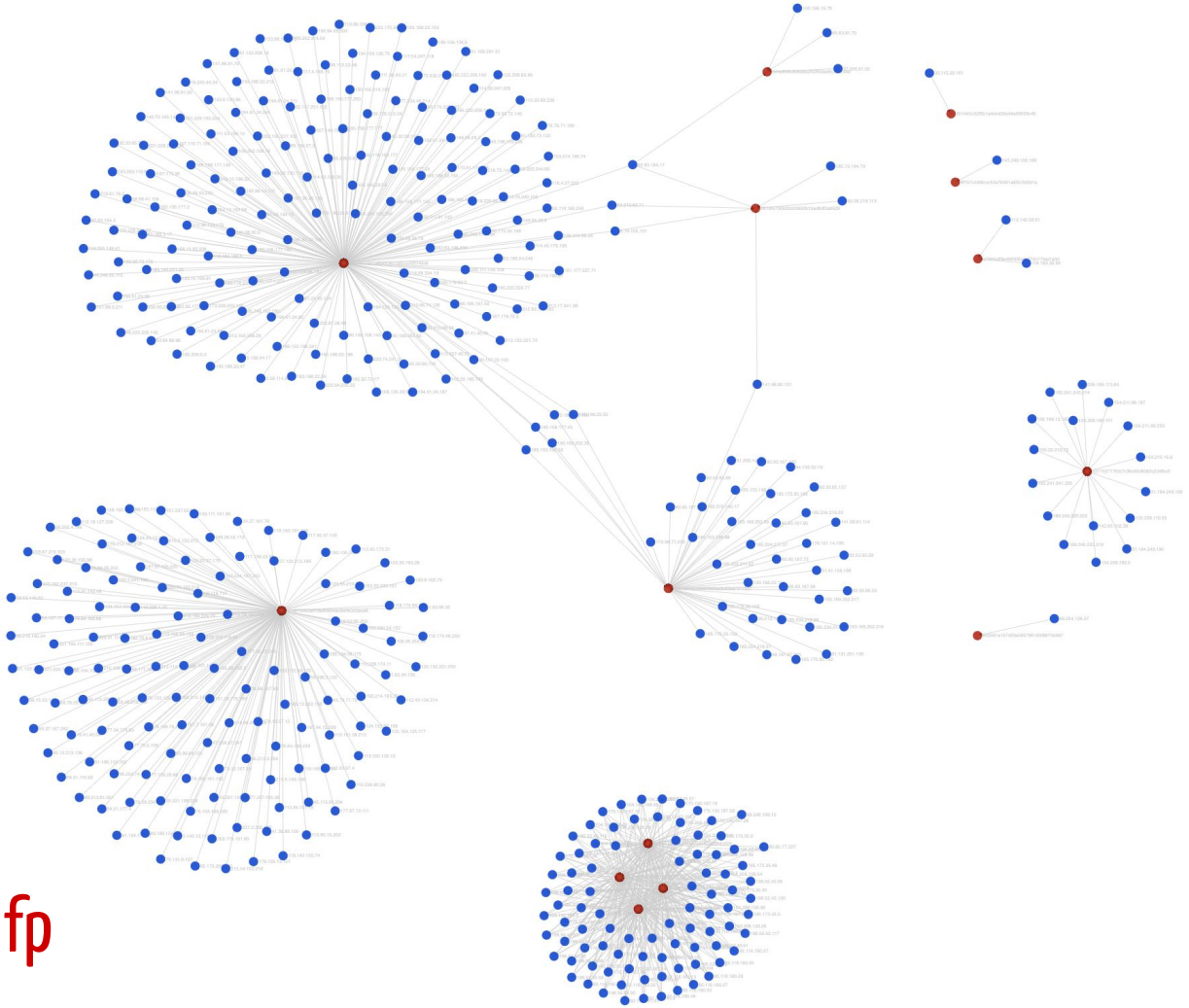
Profiling the tools and actors

_time	srcip	dstport	ja3_hash	ja3_fields	server_name
2018-02-24T07:40:06.369+0000	.159.53	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.bing.com
2018-02-24T09:21:42.033+0000	.167.122	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	5njk.com
2018-02-24T09:26:08.037+0000	.167.122	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	5njk.com
2018-02-24T09:35:11.436+0000	.167.122	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	5njk.com
2018-02-24T10:19:56.461+0000	23.69	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	ec22r.com
2018-02-24T10:20:03.276+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.yandex.com
2018-02-24T10:20:04.117+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.google.com
2018-02-24T10:20:04.521+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.bing.com
2018-02-24T10:26:20.373+0000	23.69	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	5njk.com
2018-02-24T10:26:27.401+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.google.com
2018-02-24T10:26:27.409+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.yandex.com
2018-02-24T10:26:28.537+0000	23.69	443	eae050f0cb6163c28dd34324c1e28d74	771,255-49196-49195-49188-4	www.bing.com
2018-02-24T11:53:40.309+0000	.167.122	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	mwg6aj.com
2018-02-26T15:29:02.032+0000	248.215	443	38d1c1933f0062c7c9046659faf08872	771,49200-49196-49192-4918	www.bing.com
2018-02-26T16:34:40.229+0000	.95.90	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	ec22r.com
2018-02-26T17:07:14.321+0000	248.215	443	38d1c1933f0062c7c9046659faf08872	771,49200-49196-49192-4918	5d4w7c3w.com
2018-02-26T17:07:15.601+0000	248.215	443	38d1c1933f0062c7c9046659faf08872	771,49200-49196-49192-4918	www.google.com
2018-02-26T17:07:15.940+0000	248.215	443	38d1c1933f0062c7c9046659faf08872	771,49200-49196-49192-4918	www.yandex.com
2018-02-26T17:07:16.085+0000	248.215	443	38d1c1933f0062c7c9046659faf08872	771,49200-49196-49192-4918	www.bing.com
2018-02-26T17:38:10.496+0000	192.248	443	5001b4c2a48c94b76ca1f0199345fe60	771,52392-52393-49199-4920	u8sj3.com

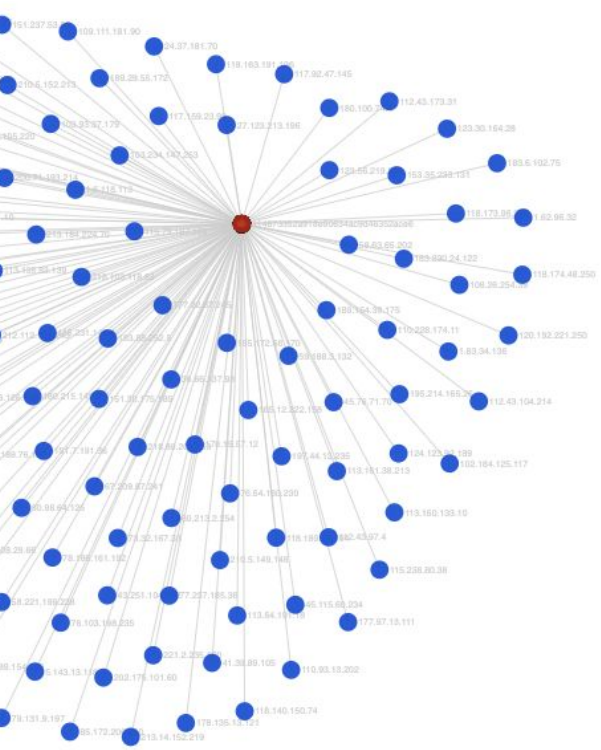
Observations

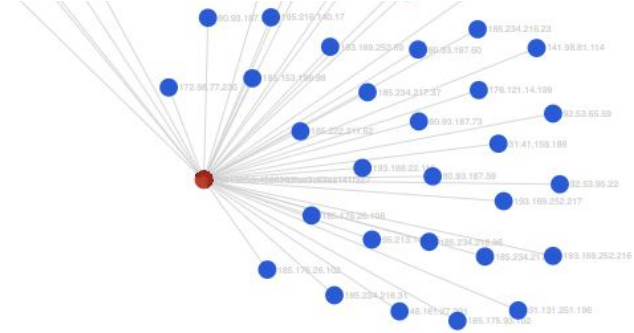
[RDP]

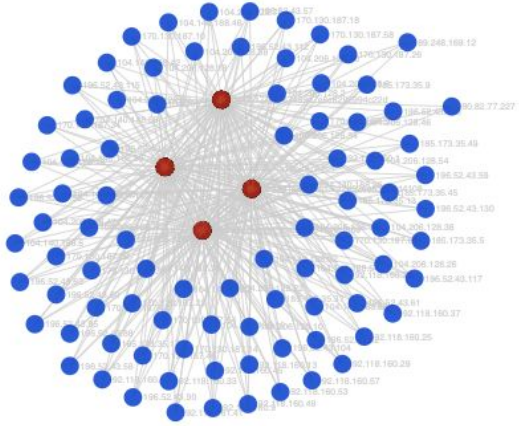

Src IP —> rdfp

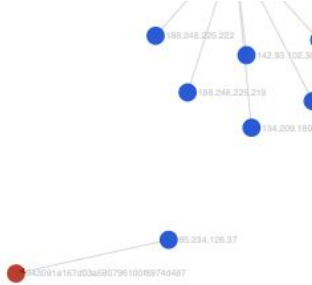


Src IP —> rdfp

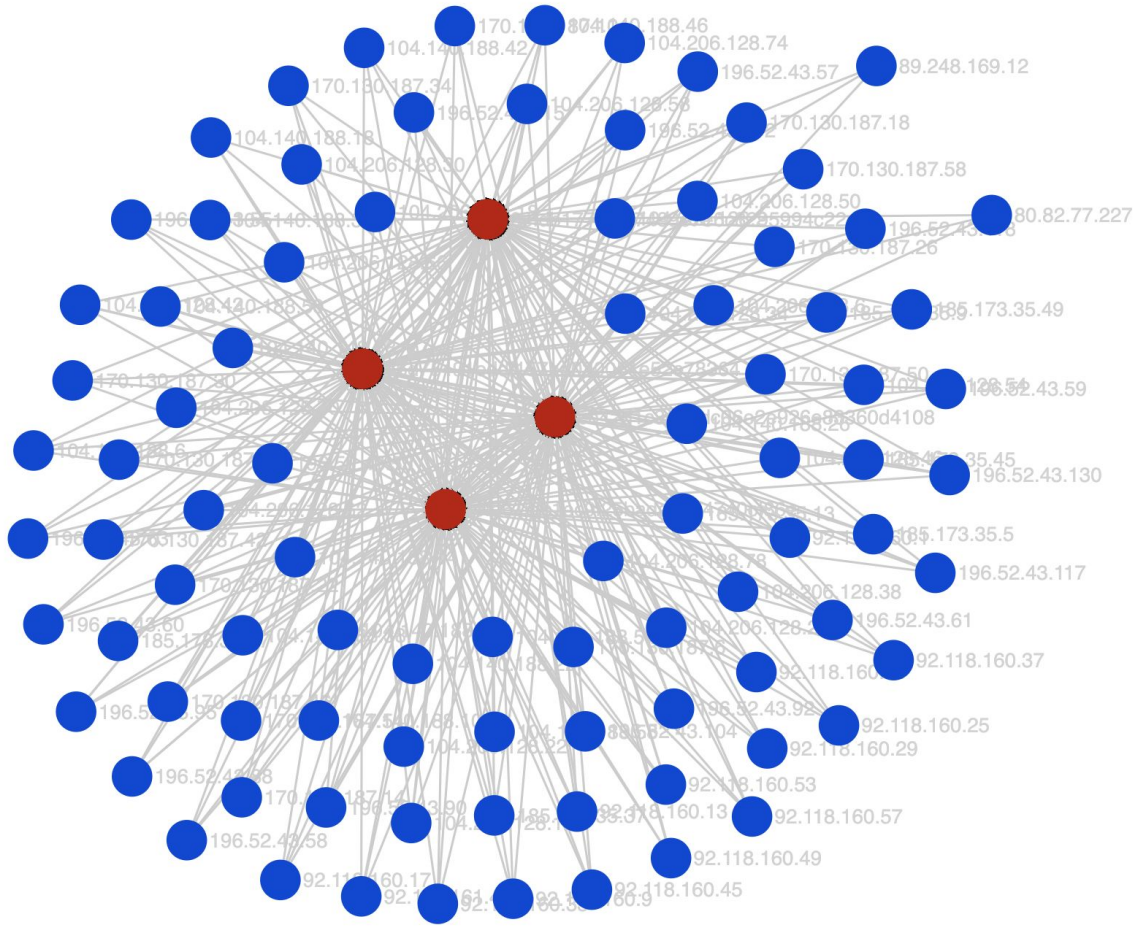








Src IP —> rdfp


104.206.128.74
196.52.43.57
89.248.169.12
170.130.187.18
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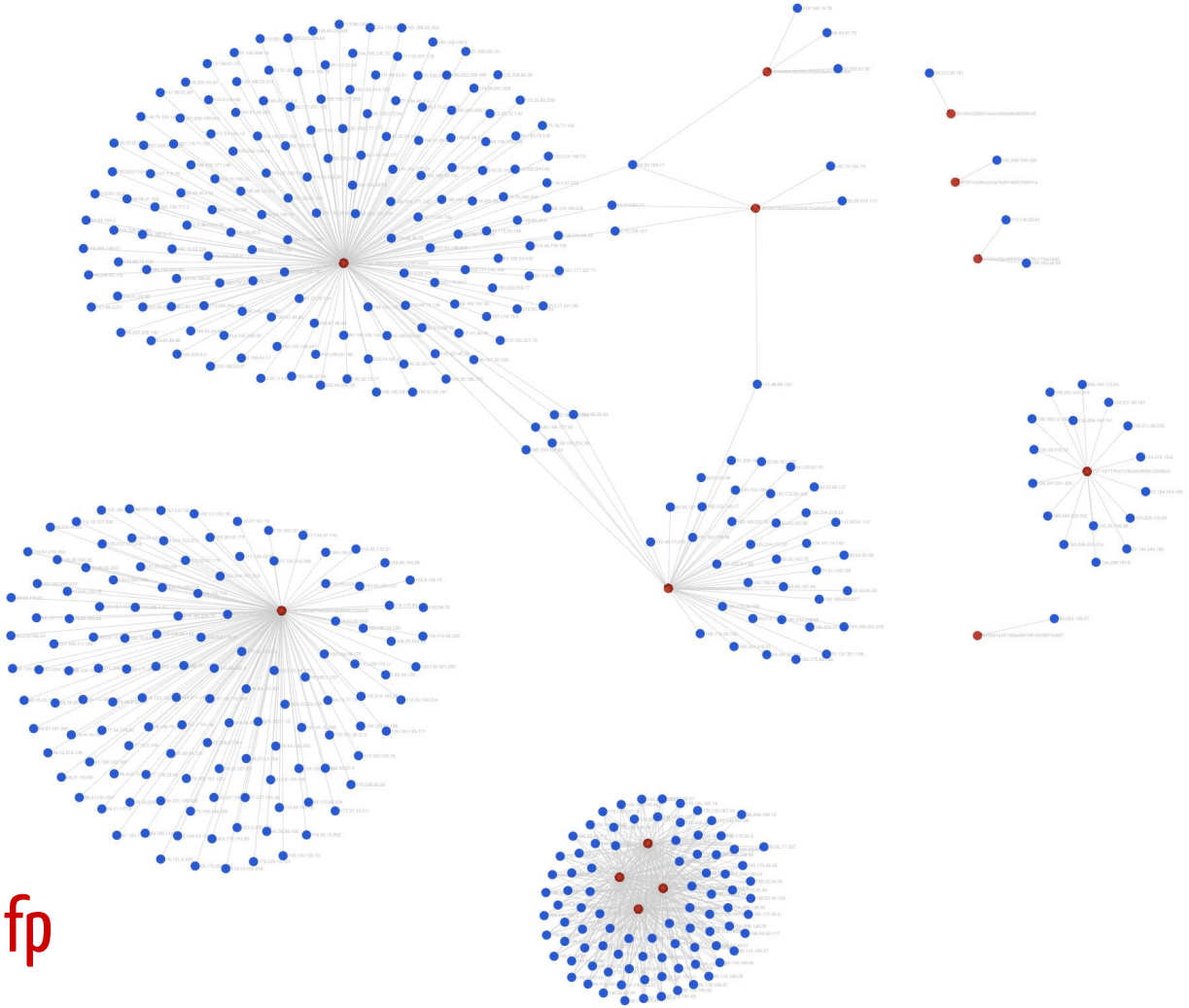
104.206.128.50
80.82.77.227
196.52.43.59
196.52.43.130
196.52.43.117
196.52.43.61
92.118.160.37
92.118.160.25
92.118.160.29
92.118.160.53
92.118.160.57
92.118.160.49
92.118.160.45

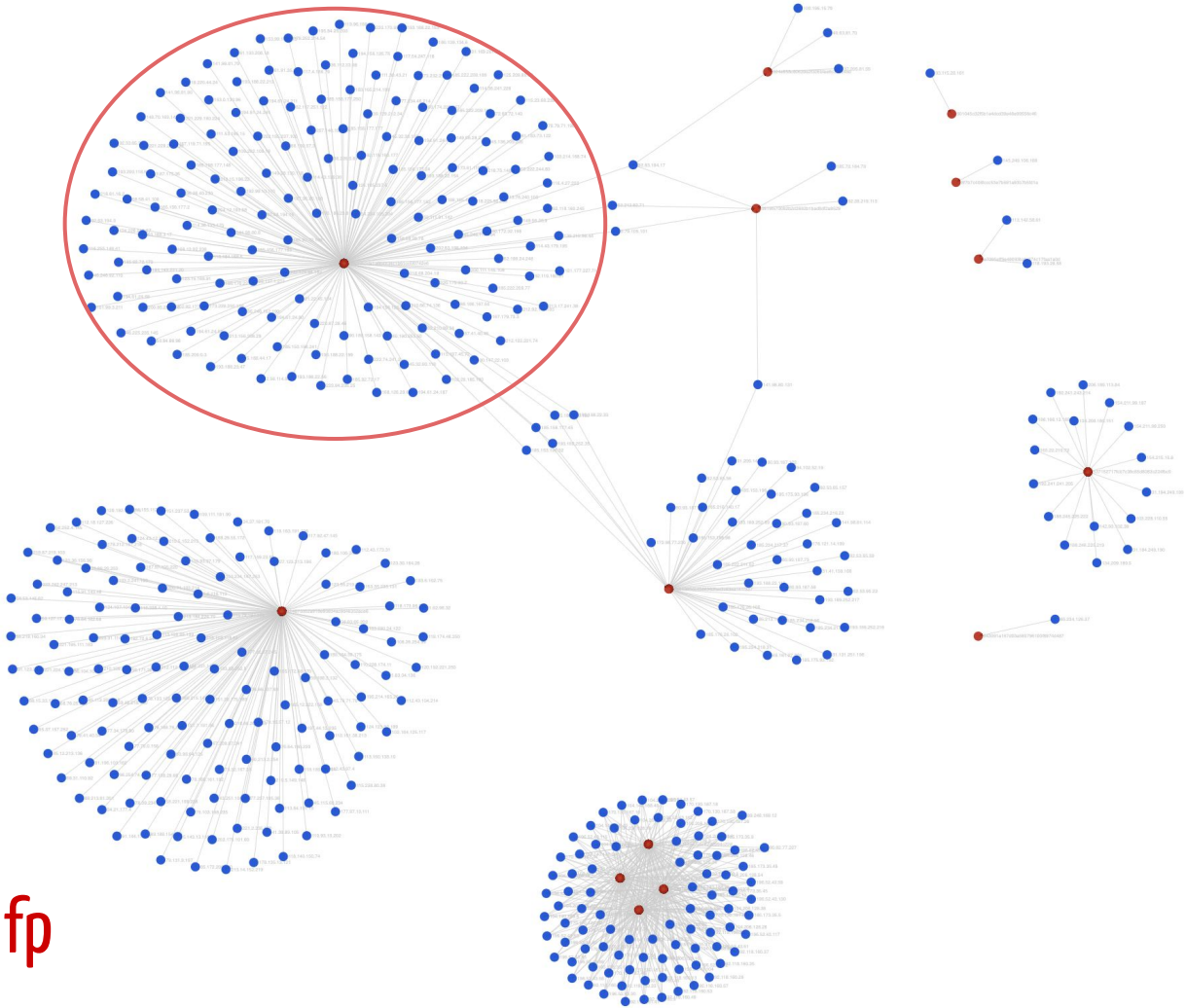
Src IP —> rdfp

Randomized RDP Cookie

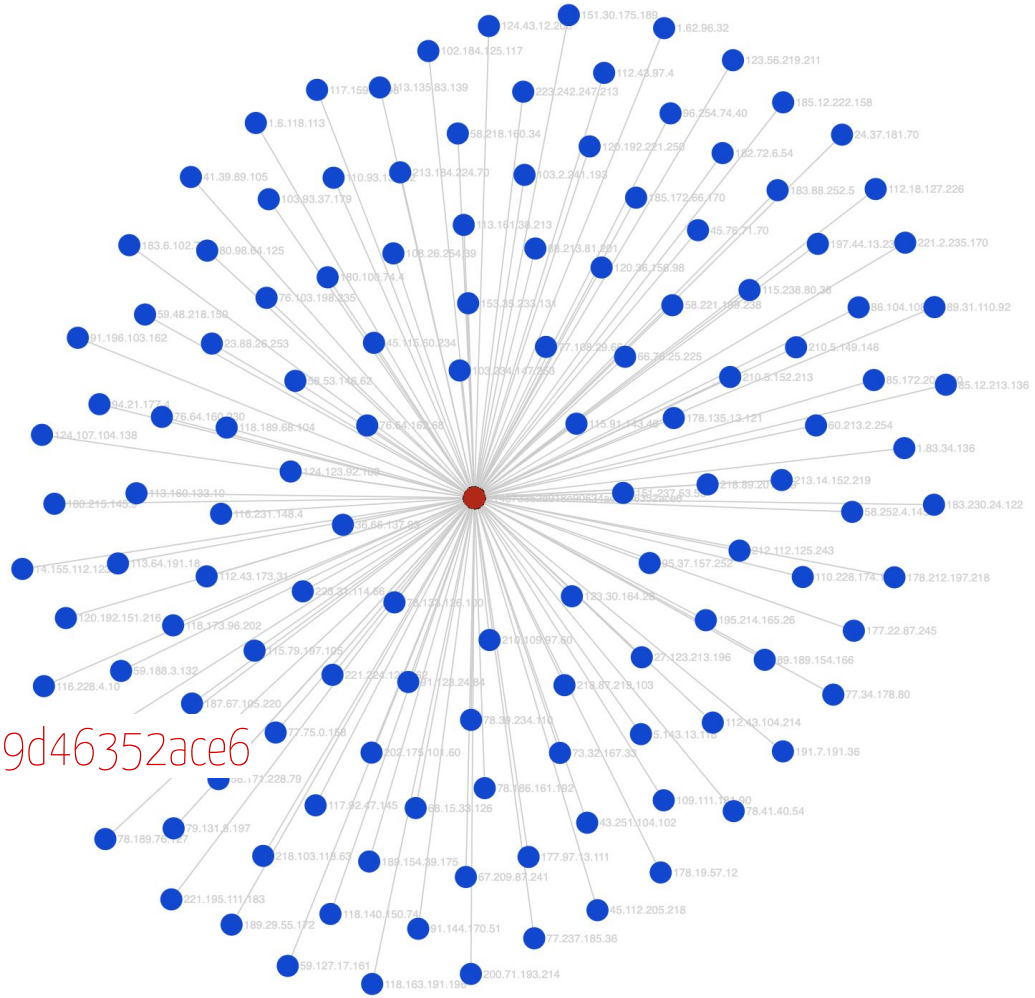
sourceIp	values(rdp.cookie)	values(rdp.rdfp)
80.82.7	mstshash=nmap	0efdb177fd787489e7e6c8295994c22d 46d75491eddf157ad030051e52e78364 cb42d1c3edbdc06e2e926e83360d4108
89.248.	mstshash=nmap	0efdb177fd787489e7e6c8295994c22d 46d75491eddf157ad030051e52e78364 cb42d1c3edbdc06e2e926e83360d4108
185.173	mstshash=gHYfbjEMP mstshash=gYrIgsrnZ mstshash=mQWBWuurb mstshash=qoXLlFizq	0efdb177fd787489e7e6c8295994c22d 46d75491eddf157ad030051e52e78364 cb42d1c3edbdc06e2e926e83360d4108 fefd61bfc1ec9f25bada8354740cf86e
170.130	mstshash=fwAeNsuDU mstshash=oYYvhHFCq mstshash=sOsMtUzuW mstshash=yBlNbiekh	0efdb177fd787489e7e6c8295994c22d 46d75491eddf157ad030051e52e78364 cb42d1c3edbdc06e2e926e83360d4108 fefd61bfc1ec9f25bada8354740cf86e
185.173	mstshash=dGioJTpEG mstshash=jXCdWwuKY mstshash=rMIRfBldR mstshash=syemUsHMN	0efdb177fd787489e7e6c8295994c22d 46d75491eddf157ad030051e52e78364 cb42d1c3edbdc06e2e926e83360d4108 fefd61bfc1ec9f25bada8354740cf86e



Src IP —> rdfp



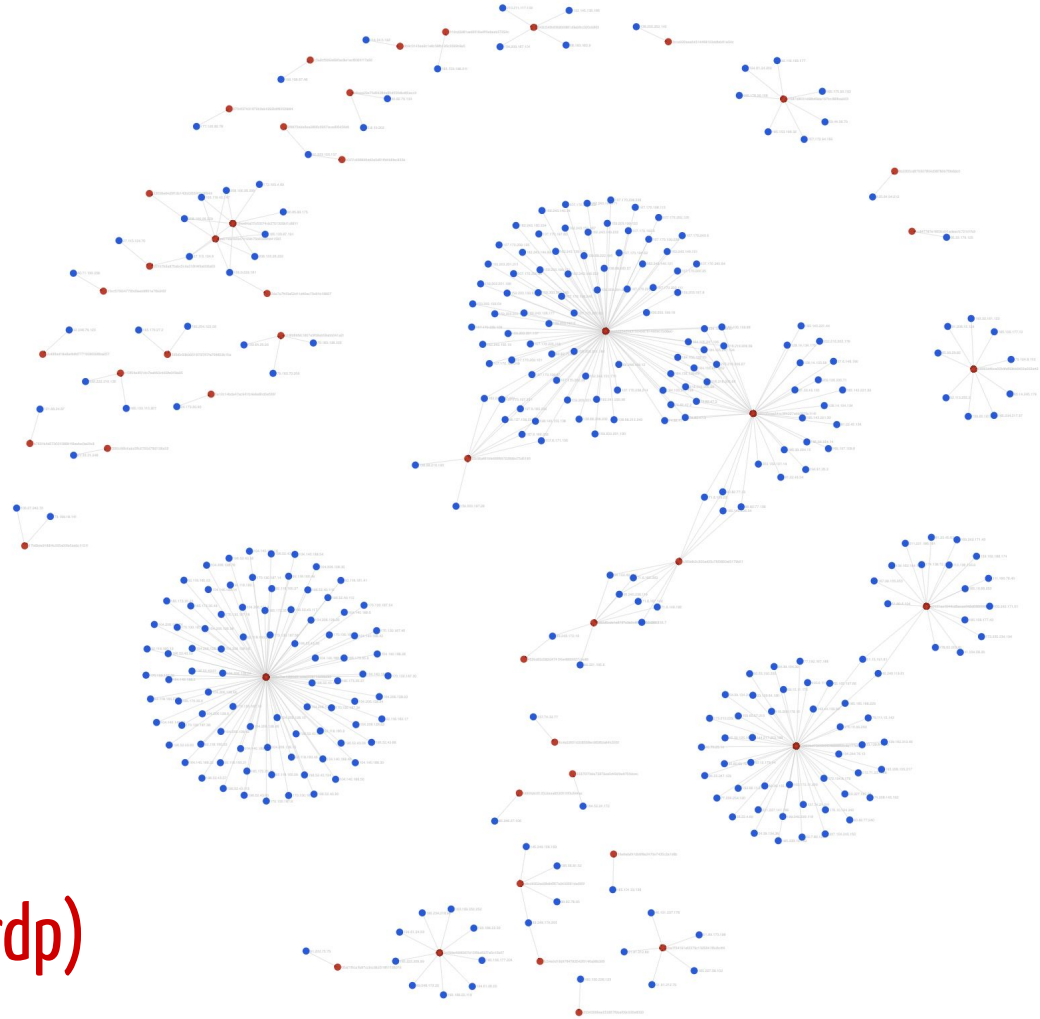
Src IP —> rdfp



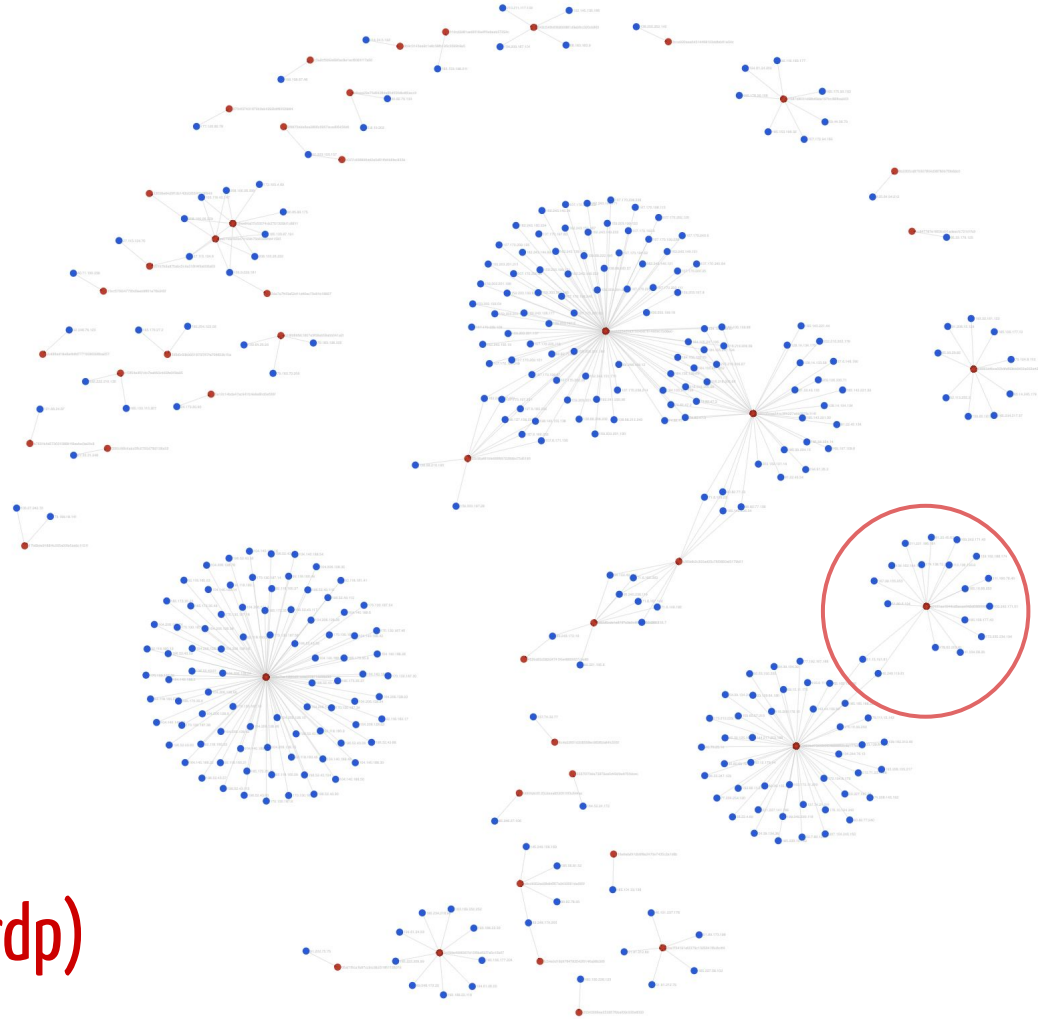
Morto malware

rdfp: a14873352a918e90634ac9d46352ace6

Src IP —> rdfp

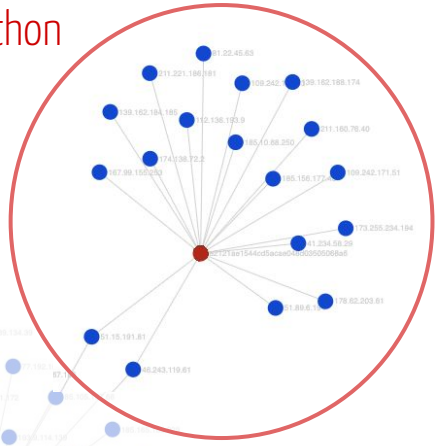


Src IP —> ja3(rdp)



Src IP —> ja3(rdp)

maybe rdpy / rdesktop / python
-> openSSL/LibreSSL-2.2.7!?



Src IP —> ja3(rdp)

Key Takeaways

- NSM is not dead!
- **Initial handshake** in cryptographic protocols is 🌟✨
- You can use network metadata and **fingerprints** for
  - Hunting badness!
  - Profiling attackers and their tools
  - Discovering new connections between the attackers/IPs!
  - Detecting evasion techniques


Thank You
@0x4d31