Przechwytywanie ruchu w niestandardowych protokołach sieciowych

OWASP
The Open Web Application Security Project

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Who are we

Sławomir Jasek

Jakub Kałużny

- Pentesters @ SecuRing
- Security assessments of applications, networks, systems...

Agenda

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- Case studies – proprietary protocols
  - Home automation
  - Pull printing #1
  - Remote desktop
  - Pull printing #2
  - Trading
- Cheatsheet for architects & developers
- How to hack it

Proprietary network protocols

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- A pentester will encounter one
- Don’t have the protocol specs nor tools to attack it
- How to hack it?
  - decompile the client?
  - search for some tools?
  - watch the raw packets?
- Let’s try!

https://www.flickr.com/photos/canonsnapper/2566562866

Home automation remote control

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- *„Plug the device, configure your router for port forwarding (and dynamic dns if necessary), set password.”*
- Proprietary TCP protocol, direct connection from Internet to device, password protected access

http://www.flickr.com/photos/99832244@N07/9436065073/

Protocol – a few packets

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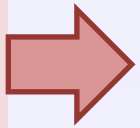
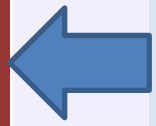
CLIENT

```
ab 55 41 00 15 39 64 64  34 65 34 36 31 32 36     .UA..9dd 4e46126
02 01 00 00 a9 39 64 64  34 65 34 36 31 32 36     .....9dd 4e46126
aa 55 41 00 14 39 64 64  34 65 34 36 31 32 36     .UA..9dd 4e46126
```

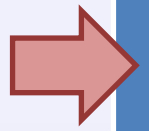


SERVER

```
aa 53 41 02 01 01 f0 f1  f1 f1 f1 00 be f1 f1 00  .SA..... ........
c4 00 e1 f1 f1 f1 f1 f1  f1 f1 f1 f1 f1 f1 f1 f1  ........ ........
f1 f1 f1 00 64 00 00 00  01 00 f0 f0 0a f1 00 02  ....d... ........
0f 0f e7
```



```
ab 55 41 00 15 39 64 64  34 65 34 36 31 32 36     .UA..9dd 4e46126
0c 02 00 00 a4 39 64 64  34 65 34 36 31 32 36     .....9dd 4e46126
aa 55 41 00 14 39 64 64  34 65 34 36 31 32 36     .UA..9dd 4e46126
```



And what if we change the password?

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Password 1:

```
00000000  aa 55 41 00 14 39 32 65  62 35 66 66 65 65 36    .UA..92e b5ffee6
    00000000  aa 53 41 02 01 01 f0 f1  f1 f1 f1 00 a1 f1 f1 00 .SA..... ........
    00000010  92 00 dd f1 f1 f1 f1 f1  f1 f1 f1 f1 f1 f1 f1 f1 ........ ........
    00000020  f1 f1 f1 00 78 00 02 00  00 00 f0 f0 07 a3 00 02 ....x... ........
    00000030  0f 0f d2                                       ...
```

Password 2

```
00000000  aa 55 41 00 14 34 61 38  61 30 38 66 30 39 64    .UA..4a8 a08f09d
    00000000  aa 53 41 02 01 01 f0 f1  f1 f1 f1 00 a1 f1 f1 00 .SA..... ........
    00000010  93 00 dd f1 f1 f1 f1 f1  f1 f1 f1 f1 f1 f1 f1 f1 ........ ........
    00000020  f1 f1 f1 00 78 00 02 00  00 00 f0 f0 07 a3 00 02 ....x... ........
    00000030  0f 0f d3                                       ...
```

Password 3

```
00000000  aa 55 41 00 14 30 63 63  31 37 35 62 39 63 30    .UA..0cc 175b9c0
    00000000  aa 53 41 02 01 01 f0 f1  f1 f1 f1 00 a1 f1 f1 00 .SA..... ........
    00000010  92 00 dd f1 f1 f1 f1 f1  f1 f1 f1 f1 f1 f1 f1 f1 ........ ........
    00000020  f1 f1 f1 00 78 00 02 00  00 00 f0 f0 07 a3 00 02 ....x... ........
    00000030  0f 0f d2                                       ...
```

Home automation protocol

Internal command (5 bytes)

MD5(password) – first 10 bytes

```
00000000  aa 55 41 00 14  39 32 65  62 35 66 66 65 65 36    .UA..92e b5ffee6
    00000000  aa 53 41 02 01 01 f0 f1  f1 f1 f1 00 a1 f1 f1 00  .SA..... ........
    00000010  92 00 dd f1 f1 f1 f1 f1  f1 f1 f1 f1 f1 f1 f1 f1  ........ ........
    00000020  f1 f1 f1 00 78 00 02 00  00 00 f0 f0 07 a3 00 02  ....x... ........
    00000030  0f 0f d2                                        ...
```

Status returned by the appliance (sensors, settings, etc).

Home automation - failures

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- Sniffing
- MITM
- Connect directly to the appliance - sniffed hash is enough

- Recommendation: SSL!

Home automation - SSL

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- Vendor: OK, we have added SSL support!

```
sslcontext = SSLContext.getInstance("TLS");
atrustmanager = new TrustManager[1];
atrustmanager[0] = new EasyX509TrustManager(null);
sslcontext.init(null, atrustmanager, null);
```

- Empty TrustManager – accepts all certificates

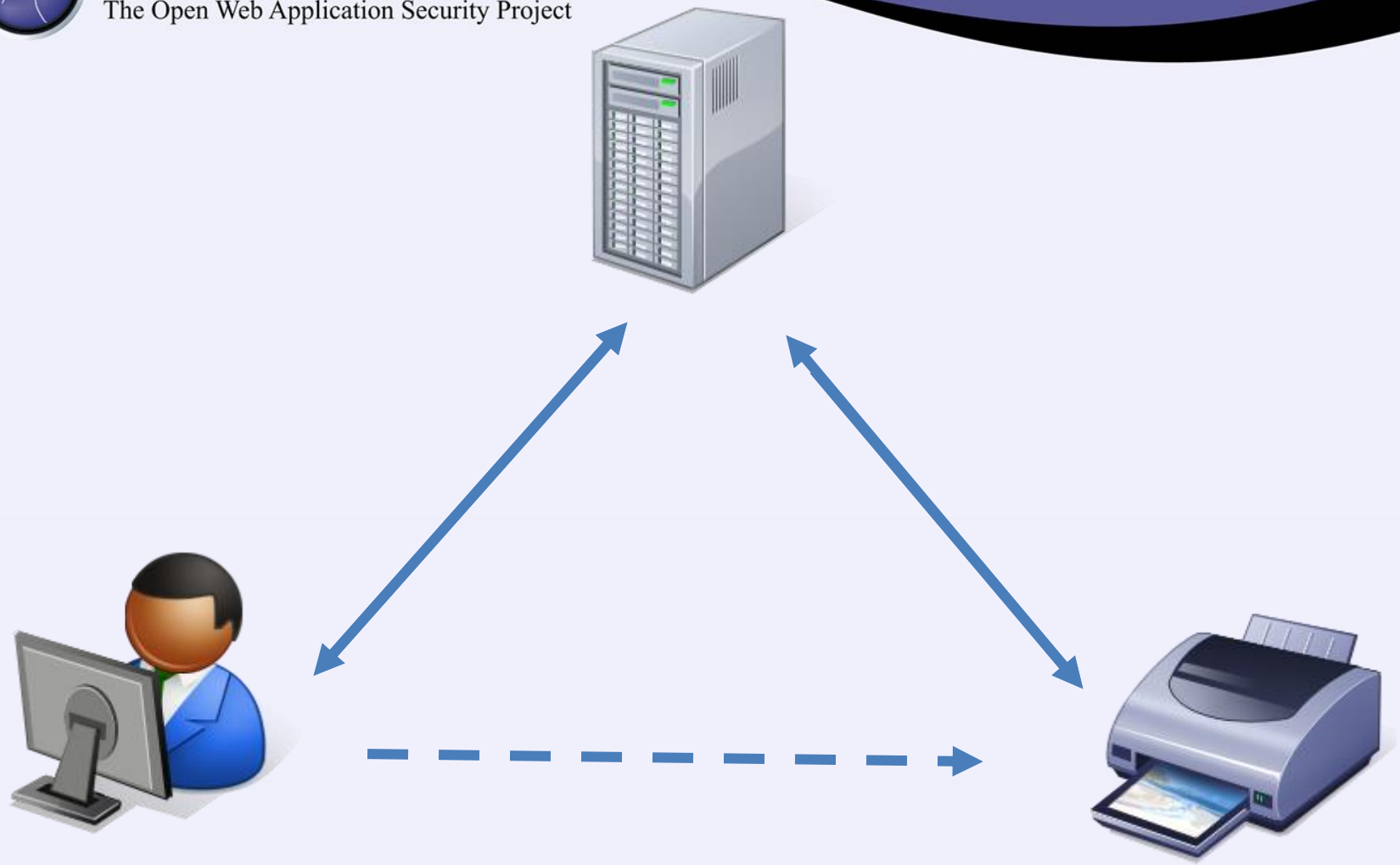
Side effect

A how to the heavy version with SSL support:

```
socat openssl-listen:1234,key=s.key,cert=s.crt,verify=0,fork,readbytes=5 /dev/ttyUSB0,vmin=51
```

```
socat openssl:1.2.3.4:1234,key=s.key,cert=s.crt,verify=0,fork,readbytes=5 /dev/ttyUSB0,vmin=51
```

Pull Printing Solutions



Why hack pull printing?

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- Widely used
- Confidential data
- Getting popular

Threat modelling – key risks

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sniffing

print queues

accountability

users' data

Attack vectors

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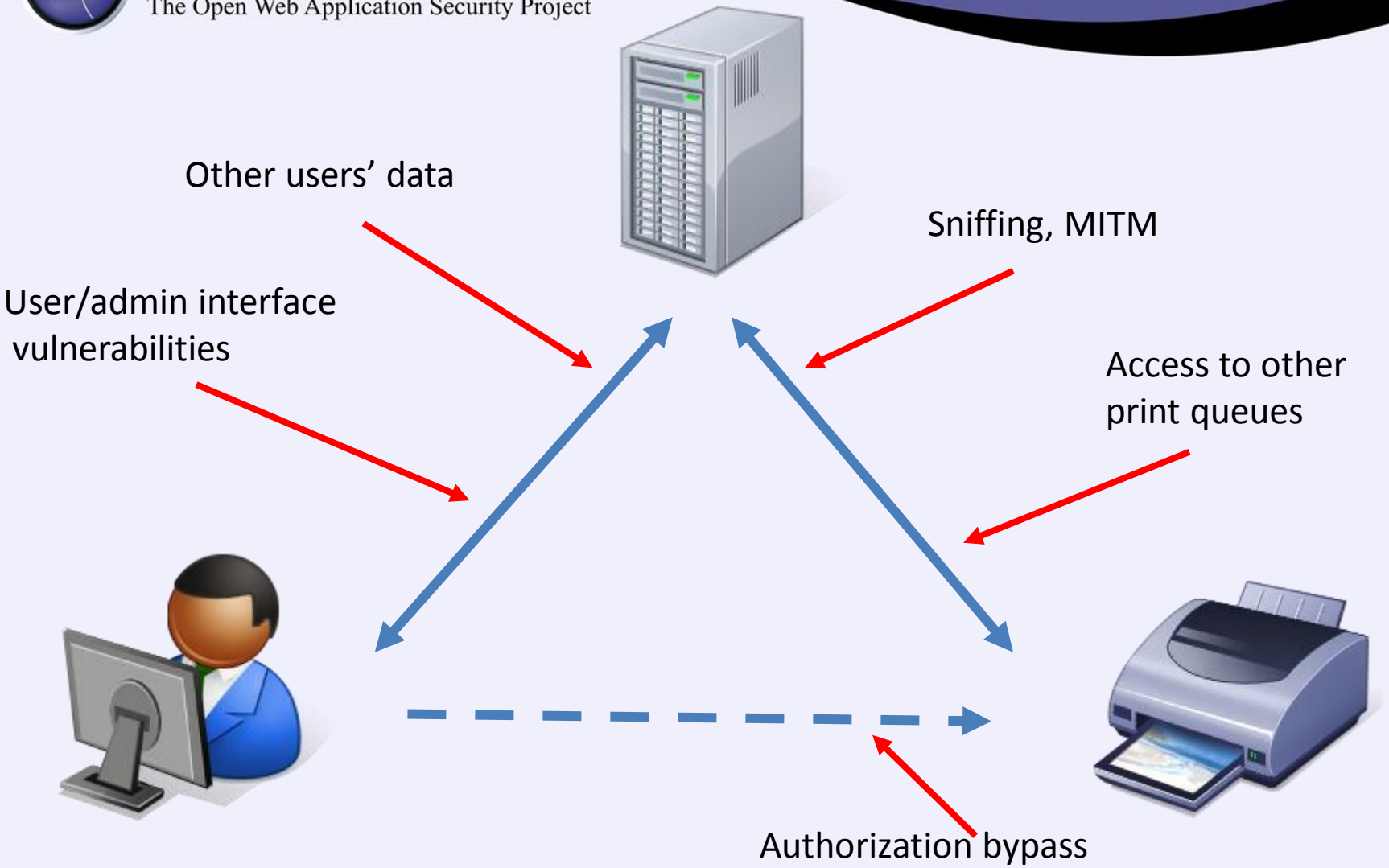

Pull Printing #1 – access control

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"**Secure print release** (…) can integrate card-swipe user authentication at devices (…) ensuring jobs are **only** printed when the collecting user is present."

Pull Printing #1 – binary protocol

Pull Printing #1 – closer look

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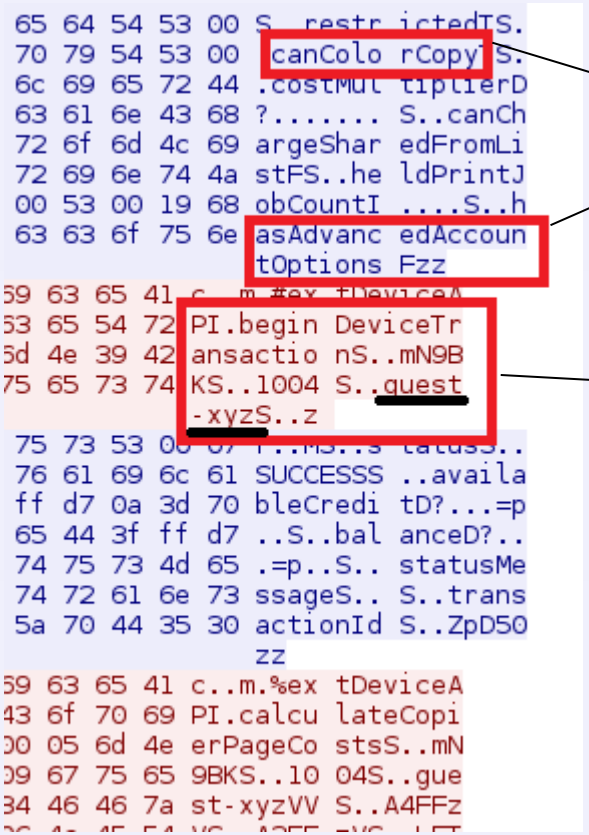
SERVER

PRINTER

Release print queue for user "guest-xyz"

Charge user "guest-xyz" for 1001 pages



Pull printing #1 - consequences

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sniffing

print queues

accountability

users' data

Pull printing #1 - vendor gets notified

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- Gave access to KB and support service
- And all versions of software
- Responded in few hours and patched in few days
- Was happy to be pentested

Remote desktop protocol

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- X-win „on steroids” (encryption, compression, access control...)
- Mainframe access for critical business operations
- *„More than 100,000 users around the world”*
- *„Prevents unauthorized eavesdropping*

  FIPS 140-2 Validated

  End-to-end data encryption”

http://en.wikipedia.org/wiki/X_Window_System_protocols_and_architecture

Remote desktop protocol

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CLIENT

```
00000000  01 01 00 00                                        ....
```

SERVER

```
00000000  01 00 00 00                                        ....
```

```
00000004  16 03 00 00 6d 01 00 00  69 03 00 52 8d e8 02 cf ....m... i..R....
```

```
00000004  11 01 30 0d 08 03 f1 00  00 00 00 00 00 00 00 00 ..0..... ........
00000014  00 ff ff 7f 00 00 01 ac  3d 08 08 68 69 6a 61 63 ........ =..hijac
00000024  6b 65 64 0a 30 35 31 45  31 45 31 41 32 36 00 01 ked.051E 1E1A26..
```

```
00000054  00 12 00 11 00 0a 00 09  00 08 00 07 00 06 00 05 ........ ........
```

LOGIN

ENCODED PASSWORD

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TestingPassword1234TestingPassword

54657374696e6750617373776f726431323334546573746 96e6750617373776f7264

XOR

1c101e1900000032080117572c1d095c475d5d3704071d060014702d1a1e1e1b1700

=

[redacted] Communications Limited

48756d6d696e67626972642043 6f6d6d756e69636174696f6e73204c696d69746564

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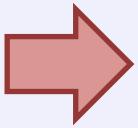
default configuration

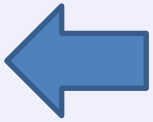
CLIENT

CLIENTHELLO!

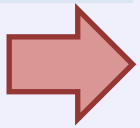
cipher suites:
SSL_DHE_RSA_WITH_AES_256_CBC_SHA
SSL_DHE_DSS_WITH_AES_256_CBC_SHA
SSL_RSA_WITH_AES_256_CBC_SHA
(...)



SERVER



SERVERHELLO!
I don't have any certificate!
cipherSuite: SSL_DH_anon_WITH_AES_256_CBC_SHA



OK, no problem! You have to be the right server if you say so, don't you?

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certificates configured

CLIENT

CLIENTHELLO!

SERVERHELLO!
I don’t have any certificate!
cipherSuite: SSL_DH_anon_WITH_AES_256_CBC_SHA

I have your certificate, but since you don’t offer it any more, I won’t check it. OK, let’s connect!

SERVER

Remote desktop protocol - vendor

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- *„We don't know PGP, use zip with our CEO's name as password"*
- Do not plan to solve the issues (?)
- > /dev/null 2>&1
- Full disclosure!
- ... and a few weeks later the mysterious shut down of our beloved ;)

Pull Printing #2 - encryption

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"is a modern printing solution that **safeguards document confidentiality** and unauthorized access to print, scan, copy and e-mail functions. Its user-authentication **provides air-tight security** on your shared MFPs that function as personal printers."

Vendor ensures

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„Documents are delivered **only** into the right hands”

„Information is kept **confidential**. **No risk** of being left unattended at the printer”

„Document collection is **safe anytime and anywhere** — no “print and sprint”.”

„Integration with other enterprise applications and workflows **is kept secure** through single sign-on”

Pull Printing #2 – binary protocol

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First look on communication:

- TCP, 2 ports
- No cleartext, no SSL
- Seems to follow some scheme…

Ex1: Deeper sight on traffic

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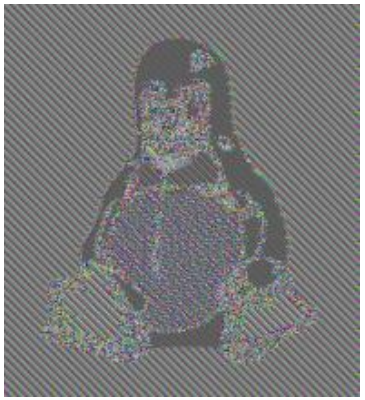
```
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..............:.c..<..~7%../}W...}....A1.......dh{hR9....
.d.._.]..y.{@...l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........a.`OVT...9/.;.s.
....q...~+..@.9.'.o.]...b..o..
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6..........l
..6............f...b...>..}U..4-{.K./o%#..;..l
..6..........l
..6..........l
..6............l).......y...^Ql
..6..........r\...ix......0.n...;4.o.....p\..gSd............qg........
+).q8...z..F..b1.Fr...l
..6..........l
..6..........l
..6..........l
..6..........l
```



https://en.wikipedia.org/wiki/ECB_mode

Pull Printing #2 - Reverse-engineered

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- Hardcoded RSA certificate in printer embedded software
- No trust store
- AES-128 ECB used for traffic encryption
- Same protocol in admin interface

Pull Printing #2 - Consequences

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sniffing

print queues

accountability

users' data

Pull Printing #1 - vendor gets notified

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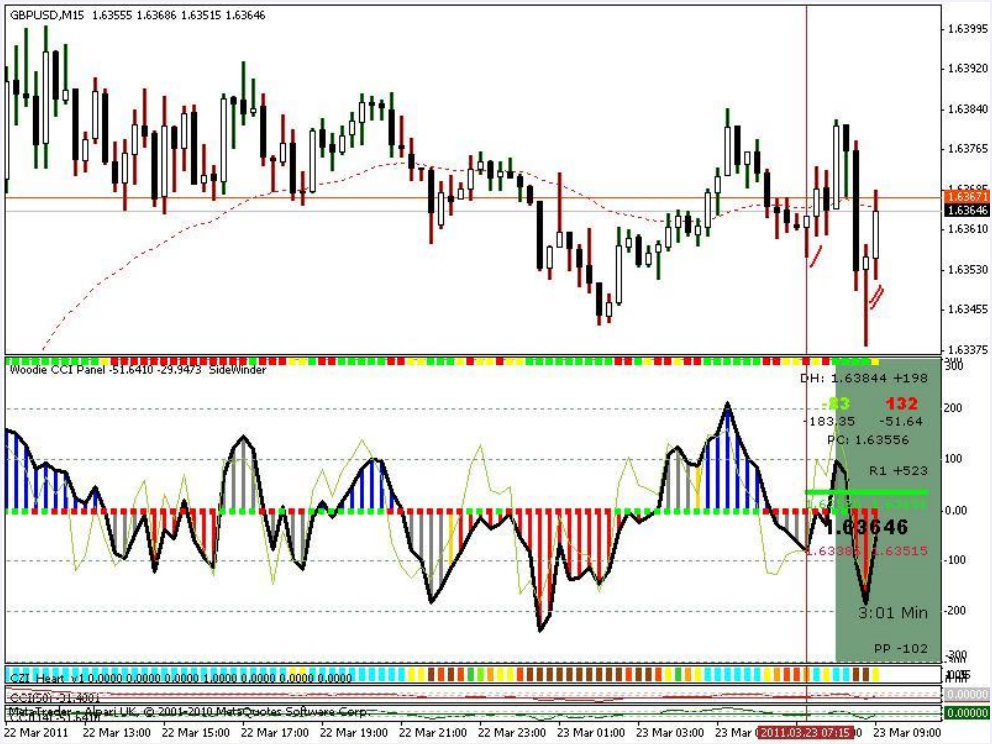
"(…) system has been deployed at many high security customers and **has passed internal audits**."

Trading protocol

- An online application for instant financial operations
- A proprietary, binary protocol, designed in order to minimise delays
- TCP in SSL tunnel



https://www.flickr.com/photos/tradingrichmom/5571144428/

Trading protocol – a few packets

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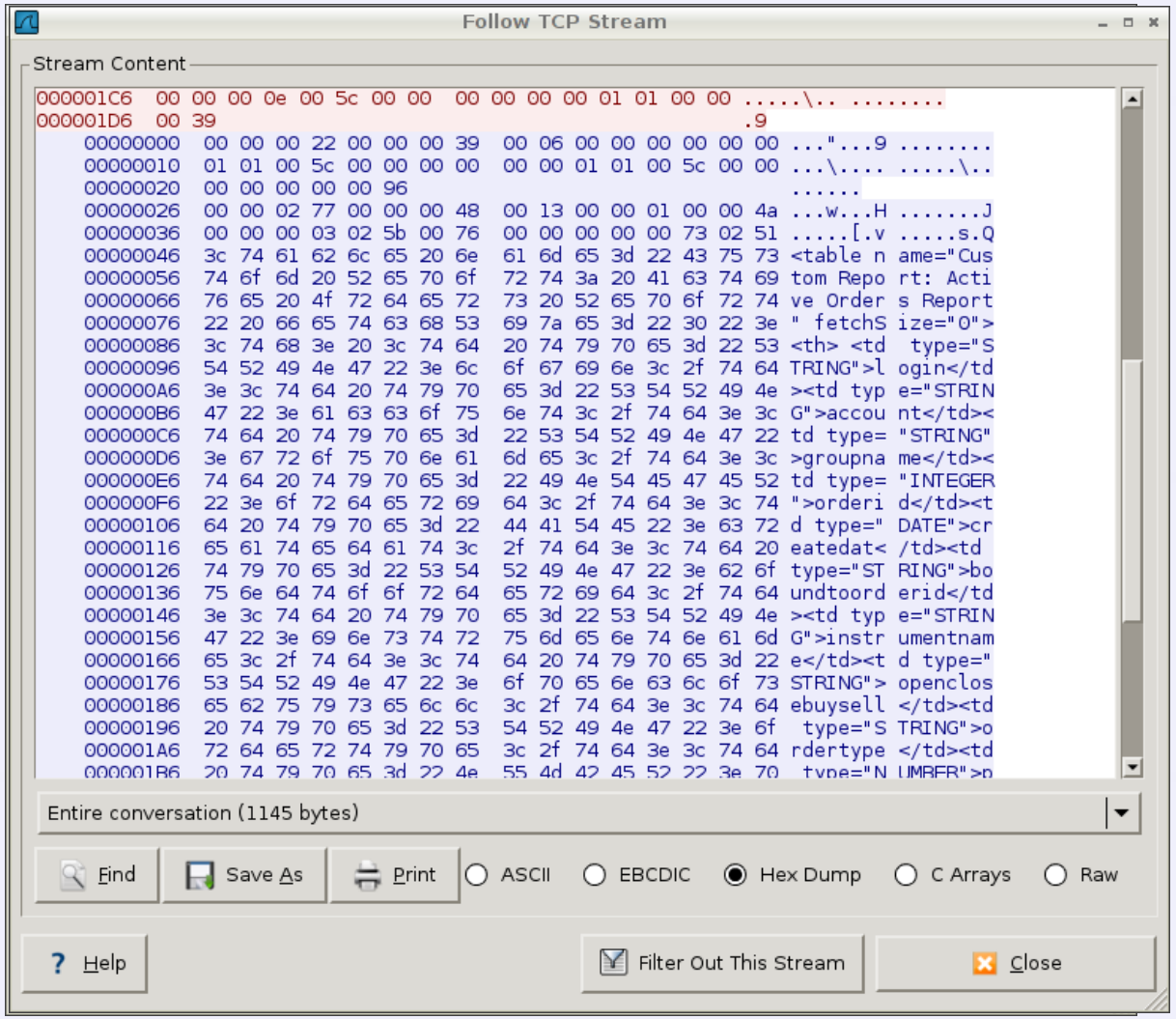

That's interesting!

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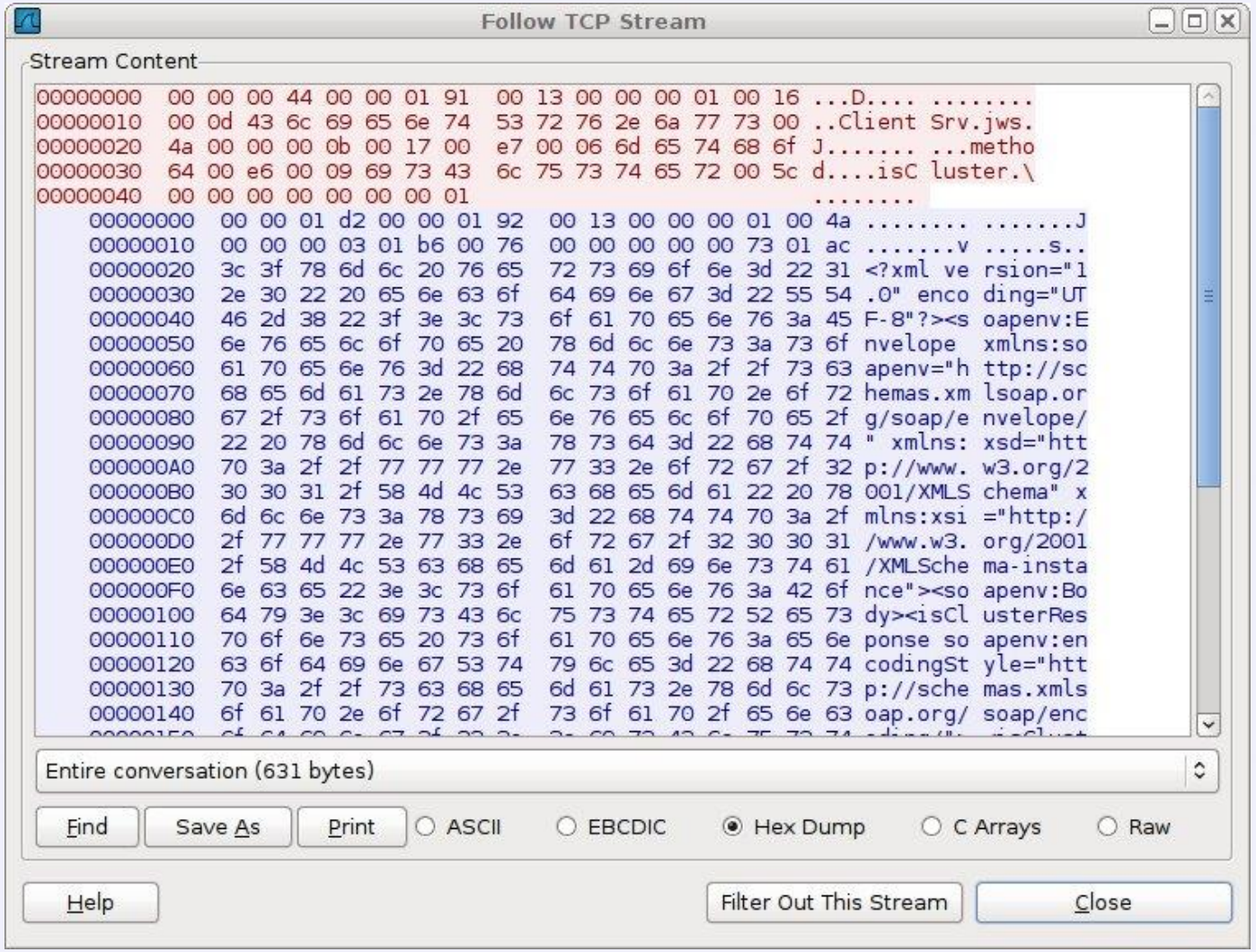

That's interesting!

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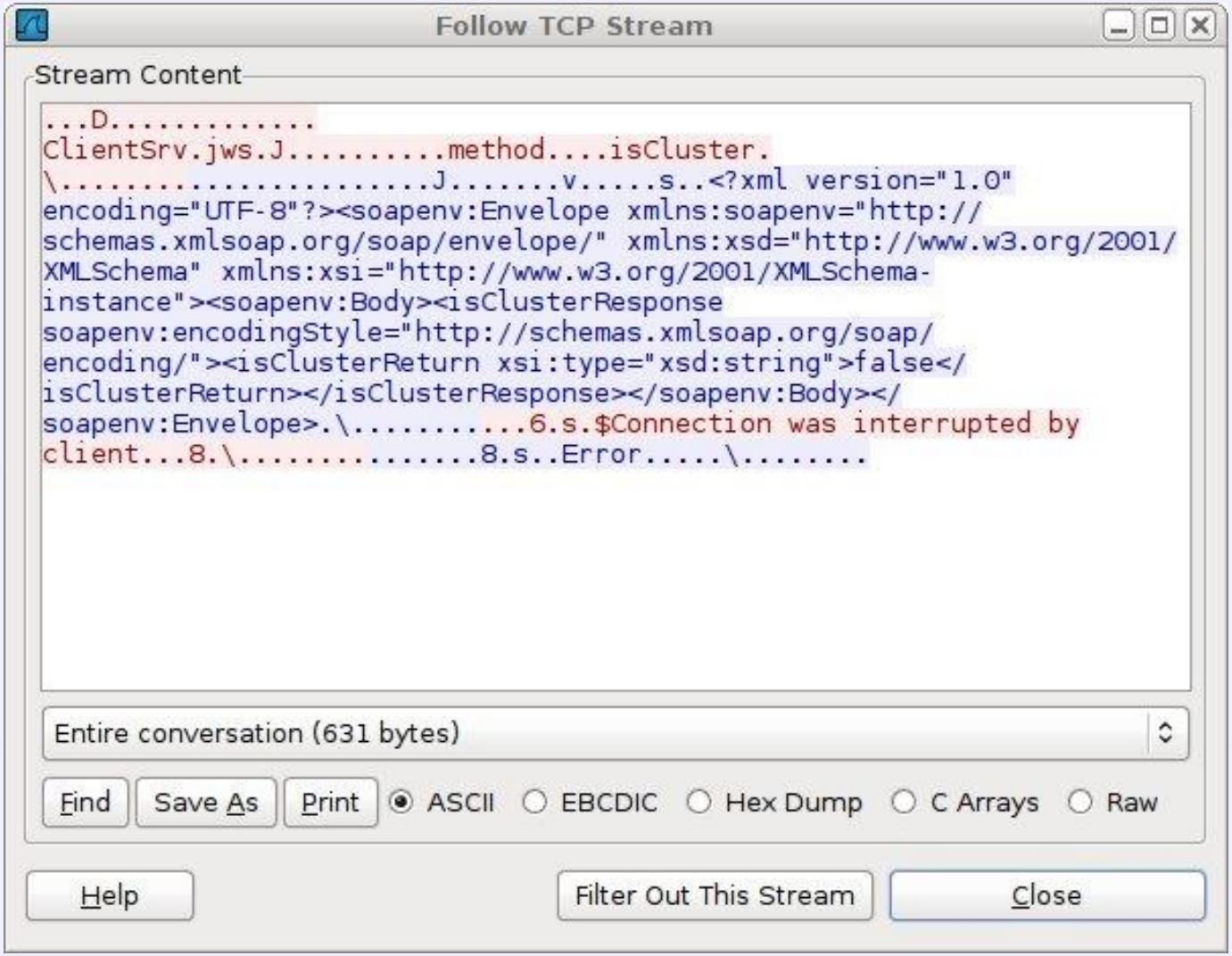

And what if we...

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Follow TCP Stream

Stream Content

```
...W.\.......?.......
AdminService..J.........method....AdminService.J.........aaa....bbb...@..........J.....
$.v.....s..<?xml version="1.0" encoding="UTF-8"?><soapenv:Envelope xmlns:soapenv="http://
schemas.xmlsoap.org/soap/envelope/" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:xsi="http://
www.w3.org/2001/XMLSchema-
instance"><soapenv:Body><soapenv:Fault><faultcode>soapenv:Server.userException</
faultcode><faultstring>java.lang.Exception: Unable to process the message -was it a valid WSDD
descriptor?</faultstring><detail><ns1:stackTrace xmlns:ns1="http://xml.apache.org/
axis/">java.lang.Exception: Unable to process the message -was it a valid WSDD descriptor?
.at org.apache.axis.utils.Admin.process(Admin.java:163)
.at org.apache.axis.utils.Admin.AdminService(Admin.java:65)
.at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
.at sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:39)
.at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:25)
.at java.lang.reflect.Method.invoke(Method.java:597)
.at org.apache.axis.providers.java.MsgProvider.processMessage(MsgProvider.java:126)
```

Entire conversation (2975 bytes)

Find | Save As | Print | (•) ASCII | ( ) EBCDIC | ( ) Hex Dump | ( ) C Arrays | ( ) Raw

Help | Filter Out This Stream | Close

And how about...

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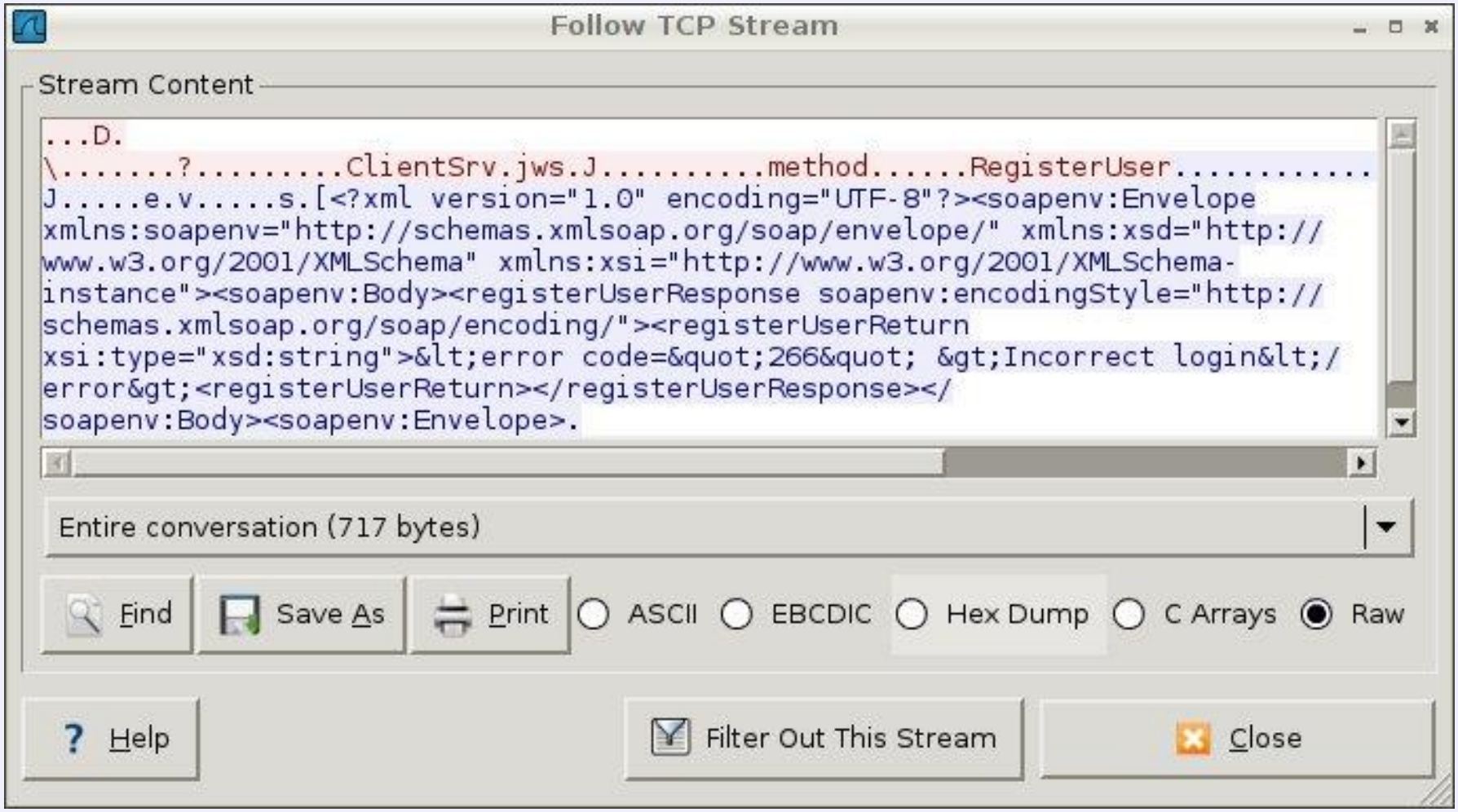

RegisterUser

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```
<soapenv:Body>
    <registerUserResponse soapenv:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
    <registerUserReturn xsi:type="xsd:string">
    &lt;error code=&quot;266&quot; &gt;Incorrect login&lt;/error&gt;
    </registerUserReturn>
    </registerUserResponse>
</soapenv:Body>
```

- Incorrect password
- Incorrect first name
- Group with name null doesn't exist
- Group with name admin doesn't exist
- Group with name Administrator doesn't exist
- And how about „root”?

Game Over

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```
<soapenv:Body>
 <registerUserResponse
   soapenv:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<registerUserReturn xsi:type="xsd:string">
User was registered sucessfully with id=5392745
</registerUserReturn>
</registerUserResponse>
</soapenv:Body>
```

So now we can manage all the other accounts and spend their money!

Architecture

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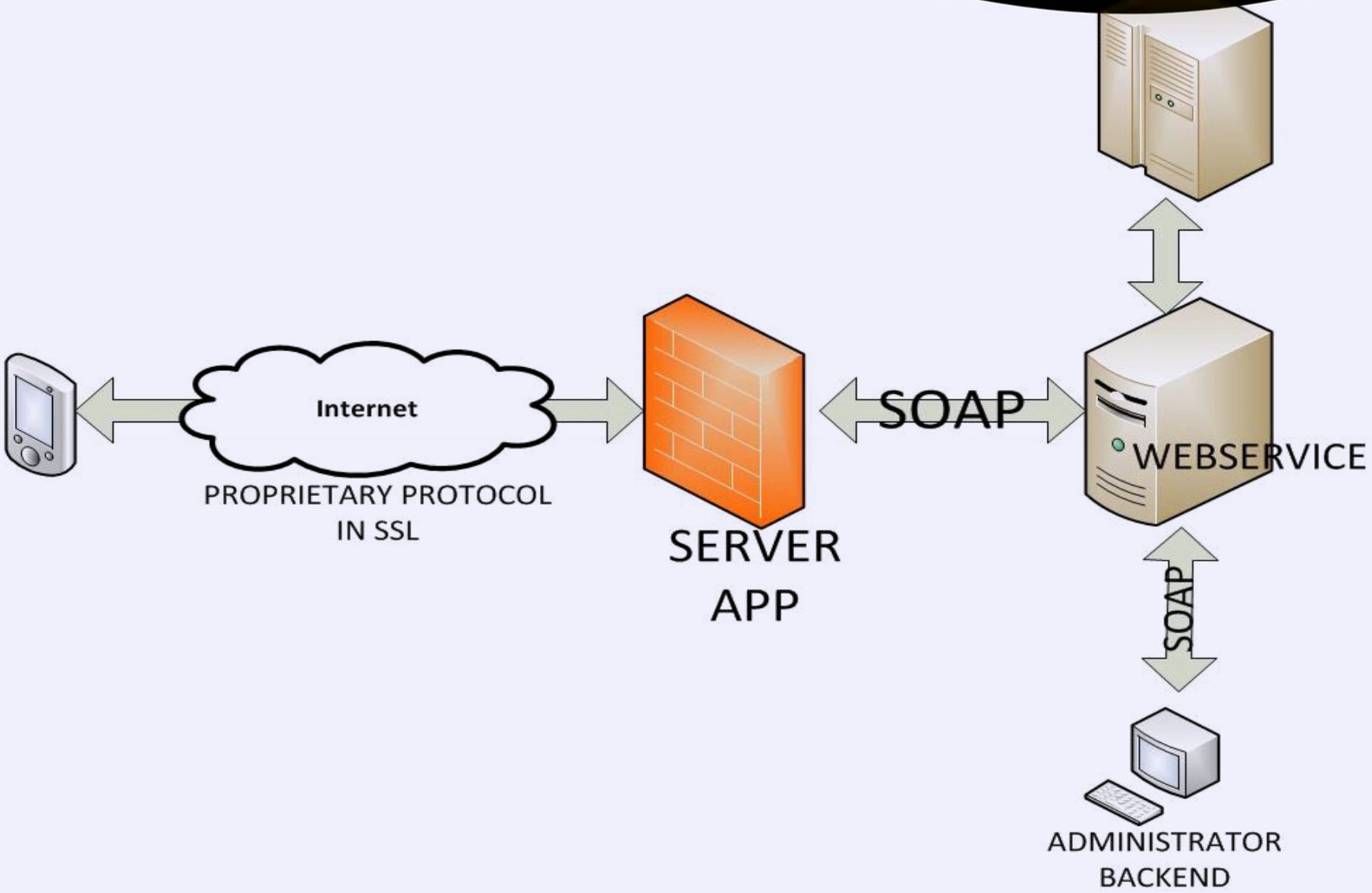

Cheat sheet – owners

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While deploying a proprietary solution:

- Get it pentested
- Verify vendor claims
- Ask the vendor for secure development lifecycle, procedures of addressing vulnerabilities, previous bugs

Cheat sheet - developers

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- Protocol is NOT secure by its secrecy
- Proper encryption. Use known standards, implement them with care.
- Input validation, access control, many layers of security, least privilege principle...
- Beware backwards compatibility

How to hack protocols?

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Decompile client?

Inject code?

Search for the specs?

Use some tools?

Watch the packets?

https://www.flickr.com/photos/nkphillips/2865781749

Look for the fine manual

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- There may be unofficial client, or e.g. wireshark plugin
- Ask for the docs ☺
- Search for them
  - Yes, we have found internal protocol specification by google hacking!

Decompile client

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- Sometimes easy – e.g. not obfuscated Android application:

```
 byte abyte3[] = pass.getBytes();
 byte abyte4[] = MessageDigest.getInstance("MD5").digest(abyte3);
 String s1 = "";
 for(int j = 0; j < 10; j++)
 s1 = (new
StringBuilder()).append(s1).append(toHexString(abyte4).charAt(j)).toString();
 System.arraycopy(s1.getBytes(), 0, abyte1, 5, 10);
```

- Sometimes really hard & time consuming.
- May be fun, but often leads astray

Watch the packets

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- Various tools to analyze proprietary protocols
  - time consuming, usually do not work
- Raw, just try to spot some scheme
  - of course with a little help of your friends: wireshark, tcpdump, ssldump etc.
- Your favourite scripting language

Q&A?

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