TLS and SSLv3 vulnerabilities explained

DRAFT

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G-SEC

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Synopsis

Around the 09/11/2009 Marsh Ray, Steve Dispensa and Martin Rex published details[1] about a vulnerability affecting the renegotiation phase of the TLS & SSLv3 protocol. The vulnerability is being tracked under CVE-2009-3555[2] | VU#120541[3] and affects a multitude of platforms and protocols, the impact of this vulnerability varies from protocol to protocol and research into those is currently ongoing.

When speaking of a "Man in the Middle" attack, it is often assumed that data can be altered or changed. Indeed an attacker that sits in the middle of a connection (hence it's name) is often able to do so. In this particular case however the attacker piggybacks an existing authenticated and encrypted TLS sessions in order to (prefix) inject arbitrary text of its choice. The attacker may not read/alter the other TLS session between the "client" and the "server". See Chapter 3 - "Example of an attack scenario..." for more details

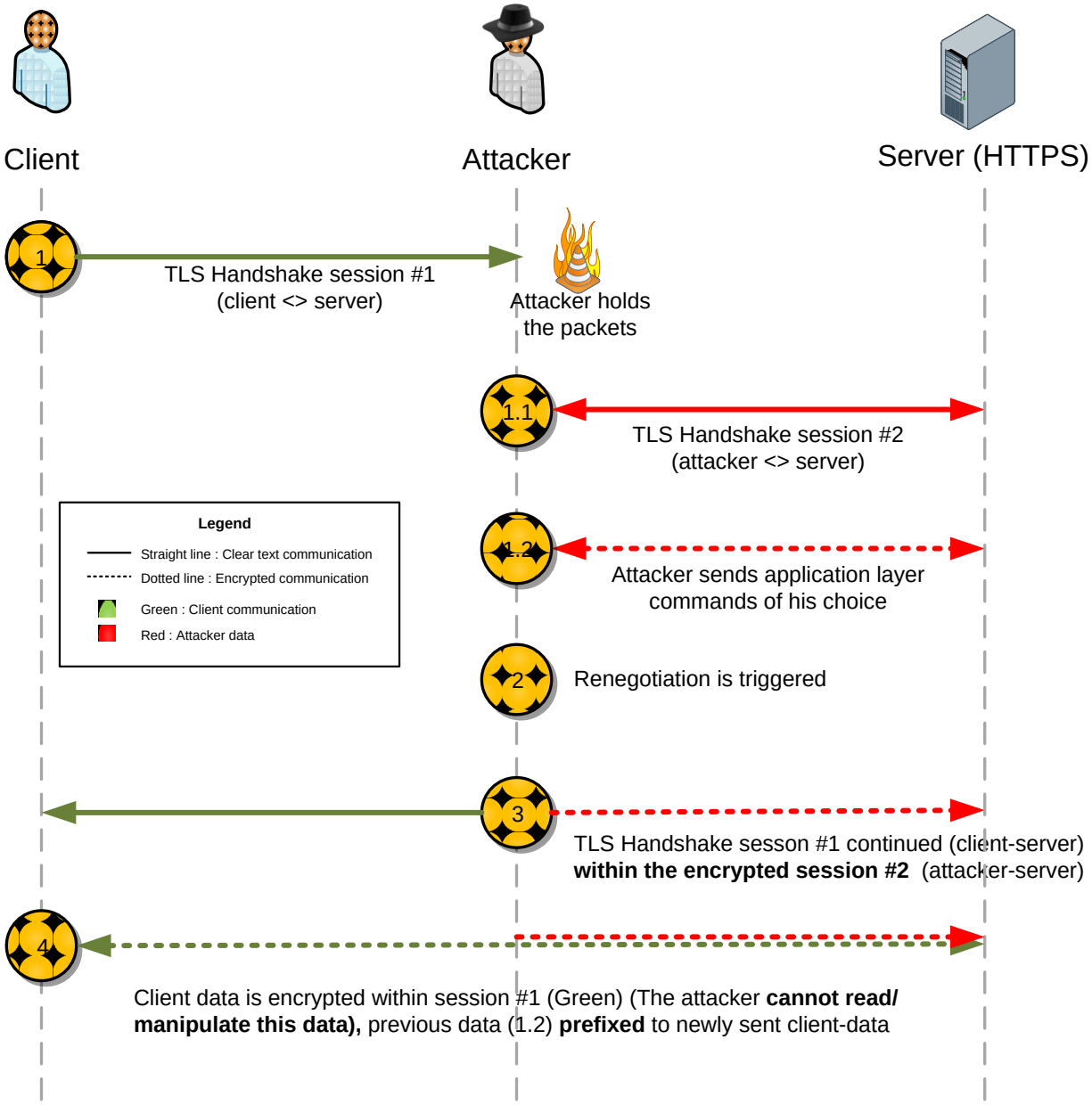
This paper explains the vulnerability for a broader audience and summarizes the information that is currently available. The document is prone to updates and is believed to be accurate by the time of writing.

Revisions

Version	*Date*	*Annotations*
0.8	09.11.2009	Initial draft
0.81	10.11.2009	Adding general and specific example
0.9	12.11.2009	Added vulnerability requirements, protocol overview
0.91	12.11.2009	Initial public draft release at http://www.g-sec.lu/
0.92	13.11.2009	Typos

[1] http://www.extendedsubset.com/
[2] http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2009-3555
[3] http://www.kb.cert.org/vuls/id/120541

Generic example: TLS renegotiation prefix injection vulnerability



Details

1 "Client" starts the TLS handshake – Attacker does not forward these immediately

1.1 The attacker negotiates a new session performs a full TLS exchange

1.2 The attacker sends application level commands over the previously established TLS session (#2)

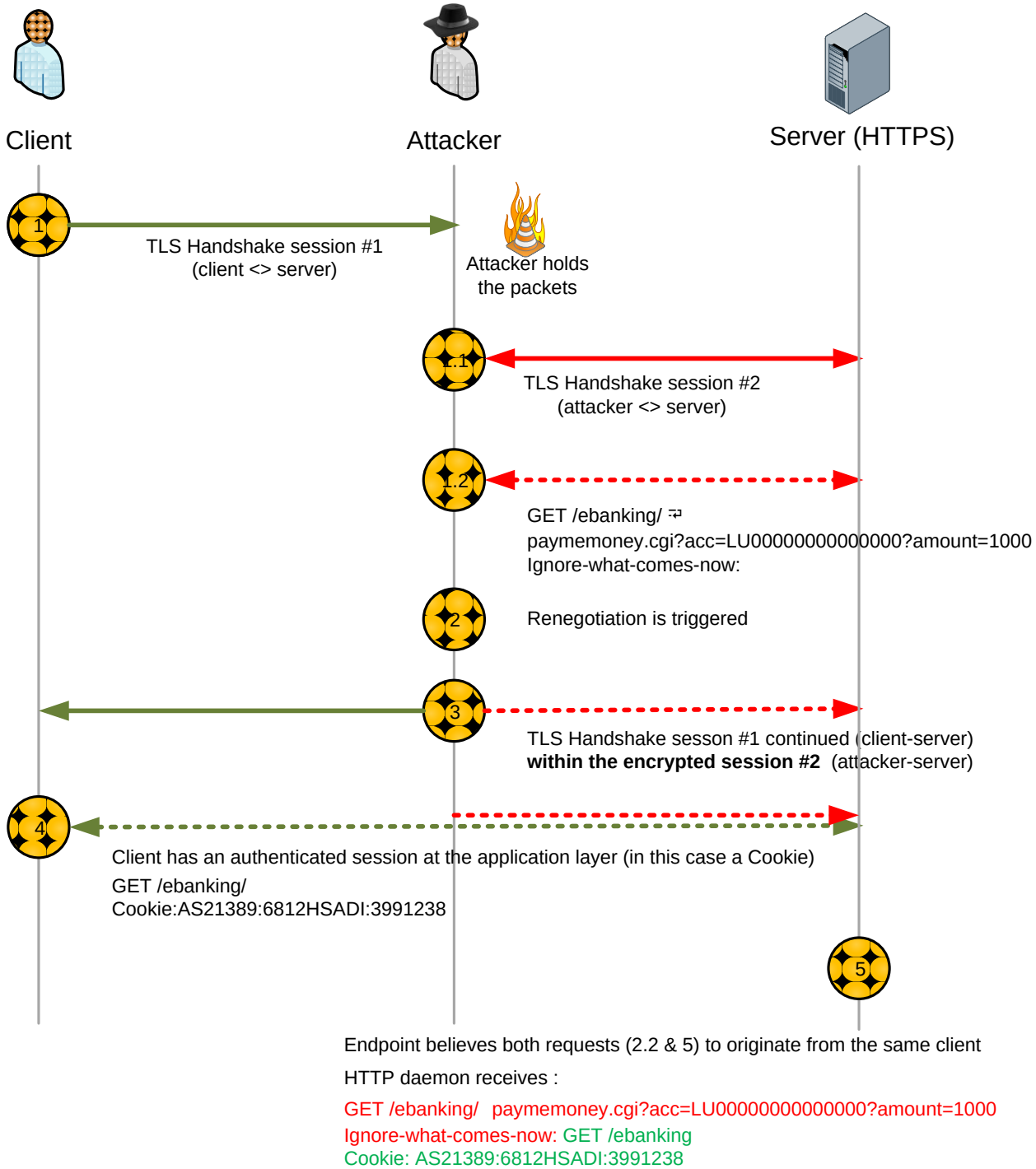
2 Renegotiation is triggered either

1. because of Certificate based auth (server sees get /dir and decides it needs an certificated for „directory")
2. due to different cipher requriements on different ressources (Server initiated)
3. by the client

3 The TLS handshake started at 1 and hold back by the attacker, is now being let to the server which performs a new TLS Handshake **over the previously established encrypted TLS session #2** (Attacker<>Server)

4 The TLS endpoint, due to the renegotiation has to take into the account the previously sent data (per spec), the endpoint believes the previous data (1.2) to have been send from the same client. As such this request is **prefixed to the one issued by the client in 4** (See HTTPS example for a more explicit example)

Specific Example : TLS renegotiation clear stream prefix injection vulnerability abusing HTTPS



Details

This is a simplistic example of how this vulnerability might be used to affect HTTPS (with client-cert, or without). We are aware that in this case a simple XSRF[4] attack could have achieved the same effect, however this is a easy to understand example

1.1 The attacker negotiates a new session performs a full TLS exchange

1.2 The attacker sends a GET request to a fictional weak e-banking application,

2 Renegotiation is triggered

3 The TLS handshake started at 1 and hold back by the attacker, is now being let to the server which performs a new TLS Handshake **over the previously established encrypted TLS session #2** (Attacker<>Server)

4 The TLS endpoint, due to the renegotiation has to take into the account the previously sent data (per spec), the endpoint believes the previous data (1.2) to have been send from the same client

The requests

1.2 : Attacker -> server

```
GET /ebanking/  paymemoney.cgi?acc=LU00000000000000?amount=1000
Ignore-what-comes-now:
```

And

4: Client->server

```
GET /ebanking
Cookie: AS21389:6812HSADI:3991238
```

5 The request is prefixed to the request issued by the client in (4)

Are merged into

```
GET /ebanking/  paymemoney.cgi?acc=LU00000000000000?amount=1000
Ignore-what-comes-now: GET /ebanking
Cookie: AS21389:6812HSADI:3991238
```

Interpreted by the HTTP daemon as :

```
GET /ebanking/  paymemoney.cgi?acc=LU00000000000000?amount=1000
Cookie: AS21389:6812HSADI:3991238
```

[4] http://en.wikipedia.org/wiki/Cross-Site_Request_Forgery

The Impact on protocols using TLS

The impact of this vulnerability is different from one protocol to another. Several stateless protocols like HTTP for instance, merge both sessions into one, making it possible for the attacker to inject arbitrary plain text into the stream that is processed by the end stream as coming from the same destination

This breaks a principal assumption made by application developers and has impacts on innumerable number of custom implementations.

Summary

Protocol	Impact analysis available	Current status
HTTPS	Yes	Vulnerable to a certain degree, impact depends on application level logic and structure of the HTTP requests.
EAP-TLS	Online discussions	Believed to not be vulnerable
IMAPS	No	Unknown
POP3S	No	Unknown
LDAPS	No	Unknown

Application	Impact analysis available	Current status
OpenVPN	Partially (vendor)	Not vulnerable, does not rely on openssl session capabilities – session handling was hardened after disclosure reports[5]
Tomcat	Partially (vendor)	Vulnerable[6] - mitigations exist
Apache	Available	Vulnerable – short term patch available[7]
IIS 7 <=7.5	Available	Vulnerable -
GNUtls	Available	Vulnerable – patch status unknown, IETF proposal currently being implemented
OpenSSL	Available	Vulnerable – short term patches available, proposal currently being implemented
JSSE / NSS	No	May be vulnerable[8]
Citrix Secure Gateway 3.1	No	Vulnerable

Please refer to VU#120541 for an updated list of applications

[5] http://www.pubbs.net/openvpn/200911/19535/
[6] http://www.mail-archive.com/users@tomcat.apache.org/msg69335.html
[7] http://marc.info/?l=apache-httpd-announce&m=125755783724966&w=2
[8] http://blogs.sun.com/security/entry/vulnerability_in_tls_protocol_during

EAP-TLS

EAP-TLS is not believed to be vulnerable if implemented as per specification[9].

- There is no application layer protocol involved when EAP-TLS is executed
- Only the TLS key material is used, the tunnel is not used.
- EAP re-authentication not the same as TLS renegotiation which is executed in the previous TLS tunnel

IMAPS

Information not available by the time of writing

POP3S

Information not available by the time of writing

[9] http://www.ietf.org/mail-archive/web/tls/current/msg04109.html

Proposed IETF solution

The IETF draft proposed by E. Rescorla, M. Ray, S. Dispensa, N. Oskov offers an elegant way to solve the problem.

The Draft proposes a new TLS extension that cryptographically binds TLS sessions to clients and further allows informing clients about renegotiations. Furthermore the proposed solution allows working with a defined rule set that allows either - Never to renegotiate - Only renegotiate if TLS negotiation extension is being used or Renegotiate anyways

As to our understanding, Openssl, Gnutls are currently implementing above proposed solution

Vulnerability requirements

The preconditions for a TLS or SSLv3 connection to be vulnerable are

1. The server acknowledges and accepts full TLS renegotiations in the middle of a connection and after the initial handshake
   and
2. The server assumes that both TLS sessions were negotiated with the same client
   and
3. The server treats both sessions as one and merges them at the application layer

As such this vulnerability might not been seen as a vulnerability in TLS but the as the bad choice to merge two different requests together by the endpoint.

Patching TLS

From the conditions that emerged in "Vulnerability conditions" the patching requirements might be:

Client

- Mid-term : Implement the IETF proposal for a TLS extension tracking and handling renegotiation requests[10] (draft-rescorla-tls-renegotiation-00.txt)

Server

- Short-term : Remove renegotiation capabilities altogether
- Mid-term : Implement the IETF proposal for a TLS extension tracking and handling renegotiation requests[11] (draft-rescorla-tls-renegotiation-00.txt)

Patching SSLv3

The only way to fix the renegotiation vulnerability for SSLv3 is to disable renegotiation on the server side completely. SSLv3 **does not support extensions** and as such cannot use the proposed extension mentioned above.

[10] https://svn.resiprocate.org/rep/ietf-drafts/ekr/draft-rescorla-tls-renegotiate.txt
[11] https://svn.resiprocate.org/rep/ietf-drafts/ekr/draft-rescorla-tls-renegotiate.txt

Conclusions

Servers

- Servers that do allow mid-connection renegotiations are vulnerable
- Applications that handle 2 TLS sessions as coming from the same client are vulnerable

Clients

- Clients have no means (pre TLS extension) to check if a renegotiation is happening are vulnerable

Sources

1. http://www.securityfocus.com/bid/36935
2. https://svn.resiprocate.org/rep/ietf-drafts/ekr/draft-rescorla-tls-renegotiate.txt
3. https://bugzilla.mozilla.org/show_bug.cgi?id=526689
4. http://blog.ivanristic.com/2009/11/ssl-and-tls-authentication-gap-vulnerability-discovered.html
5. http://www.leviathansecurity.com/pdf/ssltlstest.zip
6. http://extendedsubset.com/renegotiating_tls_20091104_pub.zip
7. https://bugzilla.redhat.com/show_bug.cgi?id=533125
8. http://www.mail-archive.com/users@tomcat.apache.org/msg69335.html
9. http://www.apache.org/dist/httpd/patches/apply_to_2.2.14/CVE-2009-3555-2.2.patch
10. http://sid.rstack.org/blog/index.php/373-tls-tout-le-monde-en-parle-pourquoi-pas-moi
11. https://www.mikestoolbox.net/
12. http://extendedsubset.com/
13. http://extendedsubset.com/Renegotiating_TLS.pdf
14. http://extendedsubset.com/Renegotiating_TLS_pd.pdf
15. http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2009-3555

Thanks

We would like to thank Noam Rathaus, j.clausing and Simon Zuckerbraun.

Disclaimer

Information is believed to be accurate by the time of writing. As this vulnerability is complex this document may be prone to revisions in the future.