Secure by default – the case of TLS

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Abstract
Default configuration of various software applications often neglects security objectives. We tested the default configuration of TLS in dozen web and application servers. The results show that “secure by default” principle should be adopted more broadly by developers and package maintainers. In addition, system administrators cannot rely blindly on default security options.

Keywords: TLS, secure defaults, testing.

1 Introduction
Security often depends on prudent configuration of software components used in a deployed system. All necessary security controls and options are there, but one have to turn them on or simply start using them. Unfortunately, the “If it ain’t broke, don’t fix it” philosophy or a lack of expertise wins sometimes. The technology is deployed in a default configuration or configuration that fulfills (mostly functional) requirements with as few changes as possible.

Secure by default is a well known security principle, see e.g. [4]:

Technology which is Secure by Default has the best security it can without you even knowing it’s there, or having to turn it on.

We should aim to provide software packages with safe defaults and turning them to less secure configuration should require a deliberate effort, see e.g. [5]:

There are many ways to deliver an “out of the box” experience for users. However, by default, the experience should be secure, and it should be up to the user to reduce their security – if they are allowed.

The Transport Layer Security (TLS) and its predecessor Secure Socket Layer (SSL) are widely used protocols for ensuring confidentiality and integrity of transported data, as well as one or two-sided authentication of communicating parties. There are various versions of the protocols and extensions proposed and implemented during more than 20 years of using SSL/TLS. Meanwhile, many flaws, both theoretical and practical were found in the design and implementation of the protocols [3] [6]. New weaknesses are constantly found; in recent years we have seen DROWN [2] or LOGJAM [1]. It is not easy to stay focused, understand the flaws and mitigate them in a timely fashion. Moreover, the compatibility with client software (web browsers) should be considered.

We tested dozen web and application servers for default SSL/TLS configuration to see how the principle of secure defaults is applied in this context. We used the default configuration of the servers, and we made minimal changes to enable SSL/TLS, usually pointing to private key and public certificate file(s). We used an excellent tool testssl.sh by Dirk Wetter [8] designed for testing servers for security weaknesses in their SSL/TLS configuration.
The results are not surprising. We observed diverse combinations of default settings. The “secure by default” principle is followed rarely. Detailed results are presented in Section 3. Let us emphasize that different versions of the servers or even the same versions packaged for another operating system or distribution can use different defaults, thus leading to different results.

2 Test environment

The test environment was based on Ubuntu 16.04 LTS distribution with up-to-date updates. We chose popular, well-known web and applications servers as well as some small players in this area. Some servers were installed from available Ubuntu repositories, some were downloaded as binaries from projects’ web sites, some were compiled from source code, and puma (a Ruby web server) was installed via RubyGems. Table 1 summarizes all twelve servers, their versions, and how they were obtained. In some cases, namely for gunicorn and puma, a minimal “Hello world!” application was created.

| server     | version   | comment                                      |
|------------|-----------|----------------------------------------------|
| apache     | 2.4.18    | package for Ubuntu 16.04                     |
| caddy      | 0.10.4    | downloaded from caddyserver.com              |
| glassfish  | 4.1.2     | downloaded from javaee.github.io/glassfish    |
| gunicorn   | 19.4.5    | package for Ubuntu 16.04                     |
| hiawatha   | 10.6      | downloaded from www.hiawatha-webserver.org, compiled |
| jetty      | 9.2.14    | package for Ubuntu 16.04                     |
| lighttpd   | 1.4.35    | package for Ubuntu 16.04                     |
| nginx      | 1.10.3    | package for Ubuntu 16.04                     |
| openlitespeed | 1.4.26 | downloaded from open.litespeedtech.com, compiled |
| puma       | 3.9.1     | installed via “gem install puma”             |
| tomcat     | 8.0.32    | package for Ubuntu 16.04                     |
| wildfly    | 10.1.0    | downloaded from wildfly.org                  |

Table 1: Versions of tested servers

Most of the servers allow fine-grained configuration of TLS support. We intentionally use the default configuration and made only minimal changes to enable TLS (following a documentation in this regard). It is not uncommon to see administrators applying such approach when managing IT systems. The tool testssl.sh was used for comprehensive test of each server’s TLS configuration.

3 Results

The results are presented in a series of tables with comments. We use marks ✓ and × to indicate supported/unsupported feature or immunity/susceptibility to a vulnerability. Moreover, we indicate by red color all those marks that we think the secure configuration should not have.

3.1 Protocol versions

There are several versions of SSL/TLS protocol. The good news is that both SSL versions (2.0 and 3.0) are disabled by default in all tested servers. The situation is more interesting for TLS versions. The majority of the servers, including “big names” like apache, nginx, tomcat or wildfly allow all three TLS versions. Two web servers caddy and hiawatha do not enable TLS 1.0 by default, which is a right thing to do. A specific case is gunicorn server — it accepts only TLS 1.0 by default. Detailed information is shown in Table 2.
Table 2: Default support for SSL/TLS protocol versions

| server   | SSL (≤ 3.0) | TLS 1.0 | TLS 1.1 | TLS 1.2 |
|----------|-------------|---------|---------|---------|
| apache   | ✗           | ✓       | ✓       | ✓       |
| caddy    | ✗           | ✗       | ✓       | ✓       |
| glassfish| ✗           | ✓       | ✓       | ✓       |
| gunicorn | ✗           | ✓       | ✗       | ✗       |
| hiawatha | ✗           | ✓       | ✓       | ✓       |
| jetty    | ✗           | ✓       | ✓       | ✓       |
| lighttpd | ✗           | ✓       | ✓       | ✓       |
| nginx    | ✗           | ✓       | ✓       | ✓       |
| openlitespeed | ✗     | ✓       | ✓       | ✓       |
| puma     | ✗           | ✓       | ✓       | ✓       |
| tomcat   | ✗           | ✓       | ✓       | ✓       |
| wildfly  | ✗           | ✓       | ✓       | ✓       |

Table 3: Categories of ciphers enabled/offered (indicated by ✓)

| server   | Cipher order | N/A/E(1) | LOW(2) | Weak(3) | TripleDES | High(4) | AEAD(5) |
|----------|--------------|----------|--------|---------|-----------|---------|---------|
| apache   | ✗            | N/A/E    | ✗      | ✗       | ✓         | ✓       | ✓       |
| caddy    | ✓            | ✓        | ✓      | ✓       | ✗         | ✗       | ✓       |
| glassfish| ✗            | ✓        | ✗      | ✗       | ✓         | ✓       | ✓       |
| gunicorn | ✗            | ✓        | ✗      | ✗       | ✓         | ✓       | ✓       |
| hiawatha | ✓            | ✓        | ✗      | ✗       | ✓         | ✓       | ✓       |
| jetty    | ✗            | ✓        | ✗      | ✗       | ✓         | ✓       | ✓       |
| lighttpd | ✓            | ✓        | ✓      | ✗       | ✓         | ✓       | ✗       |
| nginx    | ✓            | ✓        | ✓      | ✓       | ✓         | ✓       | ✓       |
| openlitespeed | ✓    | ✓        | ✓      | ✓       | ✓         | ✓       | ✓       |
| puma     | ✓            | ✓        | ✓      | ✓       | ✓         | ✓       | ✓       |
| tomcat   | ✗            | ✓        | ✗      | ✗       | ✓         | ✓       | ✓       |
| wildfly  | ✗            | ✓        | ✓      | ✓       | ✓         | ✓       | ✓       |

(1) NULL or Anonymous NULL or Export ciphers
(2) LOW — DES or 64-bit ciphers
(3) Weak 128-bit ciphers like IDEA, SEED, RC4 etc.
(4) Strong ciphers without AEAD
(5) AEAD (Authenticated Encryption with Associated Data) ciphers

A positive fact is that all servers support some cipher suites offering PFS (Perfect forward secrecy).

3.2 Ciphers

Web servers should set a reasonable cipher order for supported ciphers. Some of the tested servers do not define their cipher order at all (again, in their default configuration). Another serious weakness is using NULL cipher or obsolete export-grade ciphers — this happens in one server (gunicorn). Few servers offer weak 128-bit ciphers (RC4 or SEED). An interesting situation is the default support for TripleDES algorithm — a clear consensus is missing. A prudent approach is to turn it off.

3.3 Vulnerabilities

Not all vulnerabilities are equally dangerous. For example, not implementing TLS Fallback Signaling Cipher Suite Value or accepting ciphers in CBC mode (potentially vulnerable to LUCKY13, though the
Timing side channels are often already fixed in underlying TLS implementations) is less serious than accepting RC4 cipher or using common group of small order (LOGJAM). In some cases, the web browser used by a user determines whether the weakness is a valid threat. For example, the BEAST attack is prevented in sufficiently recent browser versions (by 1/n-1 record splitting). SSL Labs does not even track this vulnerability in their SSL Pulse anymore [7].

Table 4 contains results for the following vulnerabilities: Heartbleed (CVE-2014-0160), CCS (CVE-2014-0224), Secure Renegotiation (CVE-2009-3555), Secure Client-Initiated Renegotiation, CRIME (CVE-2012-4929), BREACH (CVE-2013-3587), POODLE (CVE-2014-3566), TLS FALLBACK SCSV (RFC 7507), SWEET32 (CVE-2016-2183, CVE-2016-6329), FREAK (CVE-2015-0204), DROWN (CVE-2016-0800, CVE-2016-0703), LOGJAM (CVE-2015-4000), BEAST (CVE-2011-3389), LUCKY13 (CVE-2013-0169), RC4 (CVE-2013-2566, CVE-2015-2808). We do not explain the vulnerabilities in detail, a curious reader can find additional information in corresponding CVEs, RFCs and references therein.

![Table 4: Default configuration potentially vulnerable (×) or not (✓)](image)

4 Conclusion

We tested dozen web and application servers for security of their default TLS configuration. The results show that "secure by default" principle is seldom followed in this, and probably other areas as well. The system administrators cannot rely blindly on default security options. This increases the (hopefully obvious) importance of thorough review and setting of security configuration.
References

[1] Adrian D., Bhargavan K., Durumeric Z., Gaudry P., Green M., Alex Halderman J., Heninger N., Springall D., Thomé E., Valenta L., VanderSloot B., Wustrow E., Zanella-Béguelin S., and Zimmermann P. Imperfect Forward Secrecy: How Diffie-Hellman Fails in Practice. 22nd ACM Conference on Computer and Communications Security (CCS ’15), 2015. [https://weakdh.org/]

[2] Aviram N., Schinzel S., Somorovsky J., Heninger N., Dankel M., Steube J., Valenta L., Adrian D., Alex Halderman J., Dukhovni V., Käsper E., Cohnéy S., Engels S., Paar C., and Shavitt Y. DROWN: Breaking TLS using SSLv2. 25th USENIX Security Symposium, 2016. [https://drownattack.com/]

[3] Meyer C., and Schwenk J. Lessons Learned From Previous SSL/TLS Attacks – A Brief Chronology Of Attacks And Weaknesses. IACR Cryptology ePrint Archive, 2013. [https://eprint.iacr.org/2013/049]

[4] The National Cyber Security Centre (NCSC). Secure by Default, 2017. [https://www.ncsc.gov.uk/articles/secure-default]

[5] The Open Web Application Security Project (OWASP). Security by Design Principles – Establish secure defaults, 2016. [https://www.owasp.org/index.php/Security_by_Design_Principles]

[6] Sheffer Y., Holz R., and Saint-Andre P. Summarizing Known Attacks on Transport Layer Security (TLS) and Datagram TLS (DTLS). RFC 7457, DOI 10.17487/RFC7457, 2015. [https://www.rfc-editor.org/info/rfc7457]

[7] SSL Labs. SSL Pulse, Qualys, August 2017. [https://www.ssllabs.com/ssl-pulse/]

[8] Wetter D. testssl.sh: Testing TLS/SSL encryption, 2017. [https://testssl.sh/, https://github.com/drwetter/testssl.sh]