Internet Engineering Task Force (IETF)
Request for Comments: 6251
Category: Informational
ISSN: 2070-1721

S. Josefsson
SJD AB

May 2011

Using Kerberos Version 5 over the Transport Layer Security (TLS) Protocol

Abstract

This document specifies how the Kerberos V5 protocol can be transported over the Transport Layer Security (TLS) protocol in order to provide additional security features.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Not all documents approved by the IESG are a candidate for any level of Internet Standard; see Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc6251.

Table of Contents

1. Introduction and Background

This document describes how a Kerberos V5 [RFC4120] implementation may upgrade communication between clients and Key Distribution Centers (KDCs) to use the Transport Layer Security (TLS) [RFC5246] protocol.

The TLS protocol offers integrity- and privacy-protected exchanges that can be authenticated using X.509 certificates, OpenPGP keys [RFC6091], and usernames and passwords via Secure Remote Password (SRP) [RFC5054].

There are several reasons to use Kerberos V5 over TLS.

- It prevents downgrade attacks affecting, e.g., encryption types and pre-auth data negotiation. The encryption type field in KDC-REQ and the METHOD-DATA field with the requested pre-auth types from the server in KDC_ERR_PREAUTH_REQUIRED errors in KDC-REP are sent without integrity or privacy protection in Kerberos V5. This allows an active attacker to replace the encryption type with a compromised encryption type, e.g., 56-bit DES, or request that clients should use a broken pre-auth type.

Since clients in general cannot know the encryption types other servers support, or the pre-auth types servers prefer or require, it is difficult for the client to detect if there was a man in the middle or if the remote server simply did not support a stronger encryption type or preferred another pre-auth type.

- Kerberos exchanges are privacy protected. Parts of many Kerberos packets are transferred without privacy protection (i.e., encryption). That part contains information, such as the client principal name, the server principal name, the encryption types supported by the client, the lifetime of tickets, etc. Revealing such information is, in some threat models, considered a problem.

- It provides additional authentication against the KDC. In some situations, users are equipped with smart cards with an RSA authentication key. In others, users have an OpenPGP client on their desktop, with a public OpenPGP key known to the server.

- It provides explicit server authentication of the KDC to the client. In traditional Kerberos V5, authentication of the KDC is proved as a side effect that the KDC knows your encryption key (i.e., your password).

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. Kerberos V5 STARTTLS Extension

The STARTTLS extension uses the Kerberos V5 TCP extension mechanism [RFC5021]. The extension uses bit 0 in the extension bitmask.

The protocol is as follows. The client requests the extension by setting the STARTTLS bit in the TCP extension mechanism bitmask. (How to deal with extension negotiation failures at this point is described in [RFC5021].) After the server has sent the 4-octet value 0x00000000 to indicate support of this extension, the stream will be controlled by the TLS protocol and its framing. The TLS protocol is initiated by the client.

Typically, the client initiates the TLS handshake protocol by sending a client hello, the server responds, and the handshake continues until it either succeeds or fails.

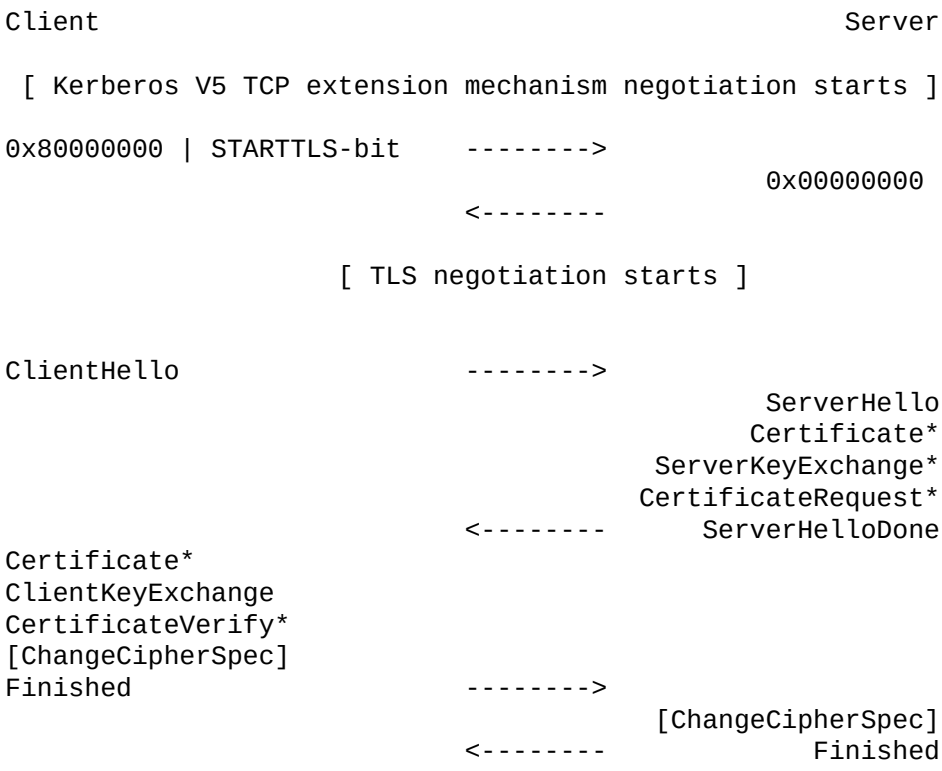
If, for any reason, the handshake fails, the STARTTLS protocol will also fail, and the TLS error is used as the error indication. In this case, no further messages can be exchanged over the same TCP session.

If the handshake succeeds, the Kerberos V5 authentication protocol is performed within the protected TLS channel, like a normal TCP Kerberos V5 exchange. In particular, this means that every Kerberos V5 packet will be prefixed by a 4-octet length field that indicates the length of the Kerberos V5 packet.

When no further Kerberos V5 messages need to be transferred in the TLS session, the TLS session MUST be shut down properly using the close_notify alert. When the TLS session is shut down, the TCP connection cannot be re-used to send any further data and MUST be closed.

3. Examples

A complete packet flow for a successful AS-REQ/REP exchange protected by this mechanism will be as follows. The "STARTTLS-bit" is a 4-octet value with only the bit allocated for this extension set, and | is the binary OR operation.



* Indicates optional or situation-dependent messages that are not always sent

4. STARTTLS-Aware KDC Discovery

Section 7.2.3 of Kerberos V5 [RFC4120] describes how Domain Name System (DNS) SRV records [RFC2782] can be used to find the address of a KDC. We define a new Service of "kerberos-tls" to indicate that the particular KDC is intended to support this STARTTLS extension. The Proto (tcp), Realm, TTL, Class, SRV, Priority, Weight, Port, and Target have the same meaning as in RFC 4120.

For example:

```
_kerberos-tls._tcp.EXAMPLE.COM. IN SRV 0 0 88 kdc1.example.com.

_kerberos-tls._tcp.EXAMPLE.COM. IN SRV 1 0 88 kdc2.example.com.
```

5. Server Certificates

The TLS protocol may be used in a mode that provides server authentication using, for example, X.509 and OpenPGP.

A goal for the protocol described in this memo is that it should be as easy to implement and deploy on clients as support for UDP/TCP. Since many client environments do not have access to long-term storage, or to long-term storage that is sufficiently secure to enable validation of server certificates, the Kerberos V5 STARTTLS protocol does not require clients to verify server certificates. If server certification had been required, then environments with constrained clients such as those mentioned would be forced to disable TLS; this would arguably be worse than TLS without server certificate validation, as the use of TLS, even without server certificate validation, protects against some attacks that Kerberos V5 over UDP/TCP does not. For example, even without server certificate validation, TLS does protect against passive network sniffing aimed at tracking Kerberos service usage by a given client.

However, note that the use of TLS without server certificate verification opens up a range of active attacks such as man in the middle.

When clients have the ability, they MUST validate the server certificate. For this reason, if a KDC presents an X.509 server certificate over TLS, it MUST contain an otherName Subject Alternative Name (SAN) identified using a type-id of id-krb5starttls-san. The intention is to bind the server certificate to the Kerberos realm for the purpose of using Kerberos V5 STARTTLS. The value field of the otherName should contain the realm as the "Realm" ASN.1 type.

```
id-krb5starttls-san OBJECT IDENTIFIER ::=
  { iso(1) identified-organization(3) dod(6) internet(1)
    private(4) enterprise(1) gnu(11591)
    shishi(6) krb5starttls-san(1) }
```

To validate a server certificate, the client MAY use local configuration (e.g., a list that maps the Kerberos realm to a copy of the server's certificate) and compare that with the authentication information provided from the server via TLS. For illustration, the

server certificate could be an X.509 certificate or an OpenPGP key. In this mode, the client needs no processing related to id-krb5starttls-san.

When the server presents an X.509 server certificate, clients MAY use "Certification Path Validation" as described in [RFC5280] to validate the KDC server certificate. In addition, unless the client can otherwise verify that the server certificate is bound to the KDC of the target realm, the client MUST verify that the server certificate contains the id-krb5starttls-san SAN and that the value is identical to the intended Kerberos realm.

6. IANA Considerations

Per [RFC5021], the IANA has allocated a bit (value 0) in the "Kerberos TCP Extensions" registry for Krb5 over TLS, the extension described in this document.

7. Acknowledgements

Miguel A. Garcia, Sam Hartman, Jeffrey Hutzelman, Magnus Nystroem, and Peter Saint-Andre (in alphabetical order) provided comments that improved the protocol and document.

8. Security Considerations

The security considerations in Kerberos V5, TLS, and the Kerberos V5 TCP extension mechanism are inherited.

Note that TLS does not protect against man-in-the-middle attacks unless clients verify the KDC's credentials (X.509 certificate, OpenPGP key, etc.) correctly. Although certificate validation adds an extra layer of protection, that is not considered strictly necessary to improve the security profile of Kerberos V5 as outlined in this document.

If server authentication is used, some information about the server (such as its name) is visible to passive attackers.

To protect against the inherent downgrade attack in the extension framework, implementations SHOULD offer a policy mode that requires this extension to always be successfully negotiated, for a particular realm, or generally. For interoperability with implementations that do not support this extension, the policy mode SHOULD be disabled by default.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC2782] Gulbrandsen, A., Vixie, P., and L. Esibov, "A DNS RR for specifying the location of services (DNS SRV)", RFC 2782, February 2000.

[RFC4120] Neuman, C., Yu, T., Hartman, S., and K. Raeburn, "The Kerberos Network Authentication Service (V5)", RFC 4120, July 2005.

[RFC5021] Josefsson, S., "Extended Kerberos Version 5 Key Distribution Center (KDC) Exchanges over TCP", RFC 5021, August 2007.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, August 2008.

[RFC5280] Cooper, D., Santesson, S., Farrell, S., Boeyen, S., Housley, R., and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", RFC 5280, May 2008.

9.2. Informative References

[RFC5054] Taylor, D., Wu, T., Mavrogiannopoulos, N., and T. Perrin, "Using the Secure Remote Password (SRP) Protocol for TLS Authentication", RFC 5054, November 2007.

[RFC6091] Mavrogiannopoulos, N. and D. Gillmor, "Using OpenPGP Keys for Transport Layer Security (TLS) Authentication", RFC 6091, February 2011.

Author's Address

Simon Josefsson
Simon Josefsson Datakonsult AB
Hagagatan 24
Stockholm 113 47
Sweden

EMail: simon@josefsson.org
URI: http://josefsson.org/