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Terminal Access Controller Access-Control System Plus (TACACS+) over TLS
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Abstract

The Terminal Access Controller Access-Control System Plus (TACACS+) Protocol provides device administration for routers, network access servers and other networked computing devices via one or more centralized TACACS+ Servers. This document adds Transport Layer Security (TLS 1.3) support to TACACS+ and obsoletes former inferior security mechanisms.

This document updates [RFC 8907](#)~~RFC8907~~.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

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1. Introduction

The Terminal Access Controller Access-Control System Plus (TACACS+) Protocol [RFC8907] provides device administration for routers, network access servers and other networked computing devices via one or more centralized TACACS+ servers. The protocol provides

~~authentication~~Authentication, ~~authorization~~Authorization, and ~~and~~
~~accounting~~Accounting services (AAA) for
TACACS+ clients within the device administration use case.

While the content of the protocol is highly sensitive, TACACS+ lacks effective confidentiality, integrity, and authentication of the connection and network traffic between the TACACS+ server and client, requiring secure transport to safeguard a deployment. The existing TACACS+ mechanisms are extremely weak as described in Section 10 of [RFC8907].

To address these deficiencies, this document updates the TACACS+ protocol to use TLS 1.3 [RFC8446] authentication and encryption, and obsoletes the use of its former mechanisms (Section 10.5 of [RFC8907]).

2. Technical Definitions

The terms defined in Section 3 of [RFC8907] are fully applicable here and will not be repeated. The following terms are also used in this document.

2.1. Obfuscation

TACACS+ was originally intended to incorporate a mechanism for securing the body of its packets. The algorithm is categorized as Obfuscation in Section 10.5.2 of [RFC8907]. The term is used to ensure that the algorithm is not mistaken for encryption. It should not be considered secure.

2.2. Non-TLS Connection

This term refers to the connection defined in [RFC8907]. It is a connection without TLS and, therefore, would be using the unsecure TACACS+ authentication and obfuscation (or the totally ~~un-obfuscated~~ option for testing). The use of well-known TCP/IP host port number 49 is specified as the default for Non-TLS connections.

2.3. TLS Connection

A TLS connection is a TCP/IP connection with TLS authentication and encryption used by TACACS+ for transport. A TLS connection for TACACS+ is always between one TACACS+ client and one TACACS+ Server.

2.4. TLS TACACS+ Server

This document describes a variant of the TACACS+ ~~Server~~server, introduced in Section 3.2 of [RFC8907], which ~~utilise~~uses TLS for transport, and makes some associated protocol ~~optimisations~~optimization. Both variants respond

to TACACS+ traffic, but we specifically define a TACACS+ ~~Server~~server (whether TLS or Non-TLS) as being bound to specific port number on a particular IP address or hostname. This definition is important in the context of the configuration of TACACS+ clients, to ensure they direct their traffic to the correct TACACS+ servers.

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«**SHOULD** be used even during test ».

I would delete the (or .. test)

2.5. Peer

The peer of a TACACS+ client (or server) in the context of a TACACS+ connection, is a TACACS+ server (or client). Together, the ends of a TACACS+ connection are referred to as peers.

3. TACACS+ over TLS

TACACS+ over TLS takes the protocol defined in [RFC8907], removes the option for MD5 obfuscation, and specifies that TLS 1.3 be used for transport (Section 3.1 elaborates TLS version support). A new well-known default host port number is used. The next sections provide further details and guidance.

TLS is introduced into TACACS+ to fulfill the following requirements:

1. Confidentiality and Integrity: The MD5 algorithm underlying the obfuscation mechanism specified in [RFC8907] has been shown to be insecure [RFC6151] when used for encryption. This prevents TACACS+ being used in a [FIPS-140-3] compliant deployment. Securing TACACS+ protocol with TLS is intended to provide confidentiality and integrity without requiring the provision of a secured network.
2. Peer authentication: The authentication capabilities of TLS replace the shared secrets of obfuscation for mutual authentication.

3.1. Separating TLS Connections

All data exchanged by TACACS+ peers MUST be encrypted, including the mutual authentication of the peers. Therefore, when a TCP connection is established for the service on the TACACS+ over TLS port number, a TLS handshake begins immediately.

To ensure separation of TACACS+ traffic that uses TLS from that which does not (Section 5.3), TLS TACACS+ ~~Servers~~servers MUST be deployed on a separate TCP/IP port number from Non-TLS TACACS+ ~~Servers~~servers (preferably on a separate host, as recommended in Section 5.1.1).

Because of the widespread use of default port number settings in numerous existing TACACS+ client configurations, a well-known system TCP/IP port number is assigned (Section 7): the designated port number is [TBD] ~~(Section 7)~~ with the service name [TBDN] ~~-(Section 7)~~. This way the client can ensure that TLS and ~~non-Non~~-TLS traffic are separated even where default port numbers are omitted from its TACACS+ server connection configuration.

Under exceptional circumstances, this document permits any other TCP port number to be configured when required by deployment specifics, but the implications in Section 5.3 have to be considered by operators.

3.2. TLS Connection

A TACACS+ client initiates a TLS connection by making a TCP connection to a configured TLS TACACS+ server on ~~the a~~ TACACS+ TLS port number ([TBD] used as default) ~~(Section 7)~~. Once the TCP connection is established, the client MUST immediately begin the TLS negotiation before sending any TACACS+ protocol data.

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TLS 1.3 [RFC8446] must be used for transport, though it is expected that TACACS+ as described in this document will work with future versions of TLS. Earlier versions of TLS MUST NOT be used.

Once the TLS connection is established, the exchange of TACACS+ data proceeds as defined in [RFC8907], except that it is transmitted over TLS as TLS application data and without TACACS+ obfuscation ~~(Section 4)~~. ~~(Section 4)~~

a mis en forme : Anglais (États-Unis)

The connection persists until ~~the one of~~ TLS TACACS+ ~~server or client peers~~ closes it, either due to an error, or at the conclusion of the TACACS+ session, or, if Single Connection Mode (Section 4.3 of [RFC8907]) has been negotiated, when an inactivity timeout occurs. Why it is closed has no bearing on TLS resumption, unless closed by a TLS error, in which case the ticket might be invalidated.

TACACS+ connections are not long-lived. Non Single Connection Mode ~~single-connect mode~~ connections are closed as soon as the TACACS+ session completes. Single Connection Mode ~~single-connect mode~~ connections are longer lived, but even these are timed out and closed after a short period of inactivity. For this reason, keepalives are not required to be supported.

TACACS+ clients and servers widely support IPv6 configuration in addition to IPv4. This document makes no changes to recommendations in this area.

3.3. TLS Authentication Options

Implementations MUST support ~~Certificate-certificate~~-based mutual authentication. Refer to Section 3.4 for specific guidance.

In addition to ~~full~~-certificate-based TLS authentication, implementations MAY support:

- * Pre-Shared Keys (PSKs) (Section 3.5), also known as Eexternal PSKs in TLS 1.3.
- * Raw Public Keys (RPKs). There is no definitive description of Raw Public Keys ~~RPKs~~ in TLS 1.3 at time of writing, so [RFC7250] must be used in context of [RFC8446]. The details of RPKs are considered out-of-scope for this document. Please refer to the RFCs above for implementation, deployment, and security considerations.

3.4. TLS Certificate Authentication

This section focuses on consideration when certificate-based TLS authentication is used.

Deploying TLS Certificate Authentication correctly will considerably improve the security of TACACS+ deployments. It is essential for implementers and operators to understand the implications of a TLS Certificate Authentication solution, including the correct handling of certificates, Certification Authorities (CAs), and all elements of TLS configuration. For guidance, please start with [BCP195].

Each peer MUST validate the certificate path of the remote peer, including revocation checking, as described in Section 3.4.1.

If the verification succeeds, the authentication is successful and the connection is permitted. Policy may impose further constraints upon the peer, allowing or denying the connection based on certificate fields or any other parameters exposed by the implementation.

Unless disabled by configuration, a peer MUST NOT permit connection of any peer that presents an invalid TLS ~~Certificate~~certificate.

3.4.1. TLS Certificate Path Verification

The implementation of ~~certificate-certificate~~-based mutual authentication MUST support certificate path verification as described in Section 6 of [RFC5280].

In some deployments, a peer could be isolated from a remote peer's ~~Certification Authority (CA)~~. Implementations for these deployments MUST support certificate chains (a.k.a. bundles or chains of trust), where the entire chain of the remote's certificate is stored on the local peer.

TLS Cached Information Extension [RFC7924] SHOULD be implemented. This MAY be augmented with Raw Public Keys [RFC7250], though revocation must be handled as it is not part of the standard.

Other approaches may be used for loading the intermediate certificates onto the client, but MUST include support for revocation checking. For example, [RFC5280] details the ~~AIA~~ (Authority Information Access (AIA)) extension to provide information about the issuer of the certificate in which the extension appears. It can be used to provide the address of the Online Certificate Status Protocol (OCSP) responder from where revocation status of the certificate (which includes the extension) can be checked.

3.4.2. TLS Certificate Identification

For the client-side validation of presented TLS TACACS+ server identities, implementations MUST follow [RFC9525] validation techniques. Identifier types DNS-ID, IP-ID, and-~~or~~ SRV-ID are applicable for use with the TLS TACACS+ protocol, selected by operators depending upon the deployment design. TLS TACACS+ does not use URI-

IDs for TLS TACACS+ server identity verification. The wildcard character MUST NOT be included in the presented TLS TACACS+ server identities.

For the TLS TACACS+ server-side validation of client identities, implementations MUST support the ability to configure which fields of a certificate are used for client identification, to verify that the client is a valid source for the received certificate and that it is permitted access to TACACS+. Implementations MUST support either:

Network address based validation methods as described in Section 5.2 of [RFC5425].

or

Client Identity validation of a shared identity in the certificate subjectAltName. This is applicable in deployments where the client securely supports an identity which is shared with the TLS TACACS+ server. Matching of dNSName and iPAddress MUST be supported. ~~Other~~ options defined in Section 4.2.1.6 of [RFC5280] MAY be supported. This approach allows a client's network location to be reconfigured without issuing a new client certificate.

Implementations MUST support the TLS Server Name Indication extension (SNI) (Section 3 of [RFC6066]). TLS TACACS+ clients MUST support the ability to configure the TLS TACACS+ server's domain name, so that it may be included in the SNI "server_name" extension of the client hello. ~~This name~~ is distinct from the IP Address or hostname configuration used for the TCP connection. See Section 5.1.5 for security related operator considerations.

Certificate provisioning is out of scope of this document.

3.4.3. Cipher Suites Requirements

Implementations MUST support the TLS 1.3 mandatory cipher suites (Section 9.1 of [RFC8446]). Readers should refer to [BCP195]. The cipher suites offered or accepted SHOULD be configurable so that operators can adapt.

3.5. TLS PSK Authentication

As an alternative to ~~Certificate-certificate~~-based authentication, implementations MAY support ~~Pre-Shared Keys~~ (PSKs), also known as External PSKs in TLS 1.3 [RFC8446]. These should not be confused with resumption PSKs.

The use of External PSKs is less well established than certificate-based authentication. It is RECOMMENDED that systems follow the directions of Section 4 of [RFC8446], and ~~[RFC9257].~~ ~~[RFC9257]~~

Where PSK ~~Authentication~~ authentication is implemented, PSK lengths of at least 16 octets MUST be supported.

PSK Identity MUST follow recommendations of Section 6.1 of [RFC9257].

Implementations MUST support PSK identities of at least 16 octets.

Although this document removes the option of MD5 obfuscation (Section 4), it is still possible that the TLS and ~~non-Non~~-TLS versions of TACACS+ may exist in an ~~organisation~~organization, for example, during migration (see Section 6.1). In such cases, the shared secrets configured for TACACS+ obfuscation clients MUST NOT be the same as the PSKs configured for TLS clients.

3.6. TLS Resumption

~~The TLS Resumption-resumption~~protocol, detailed in [RFC8446], can minimize the number of round trips required during the handshake process. If a TLS client holds a ticket previously extracted from a NewSessionTicket message from ~~the-a~~ TLS TACACS+ server, it can use the PSK identity tied to that ticket. If the TLS TACACS+ server consents, the resumed session is acknowledged as authenticated and securely linked to the initial session.

The client SHOULD use resumption when it holds a valid unused ticket from the TLS TACACS+ server, as each ticket is intended for a single use only and will be refreshed during resumption. The TLS TACACS+ server can reject a resumption request, but the TLS TACACS+ server SHOULD allow resumption as long as the ticket in question has not expired and has not been used before.

When a TLS TACACS+ server is presented with a resumption request from the TLS client, it MAY still choose to require a full handshake. In this case, the negotiation proceeds as if the session was a new authentication, and the resumption attempt is ignored. As described in Appendix C.4 of [RFC8446], reuse of a ticket allows passive observers to correlate different connections. TLS TACACS+ clients and servers SHOULD follow the client tracking preventions in Appendix C.4 of [RFC8446].

When processing TLS resumption, certificates must be verified to check for revocation during the period since the last NewSessionTicket Message.

The resumption ~~"ticket lifetime"~~ticket_lifetime SHOULD be configurable, including a zero seconds lifetime. Please refer to Section 4.6.1 of [RFC8446] for guidance on ticket lifetime.

4. Obsolescence of TACACS+ Obfuscation

[RFC8907] describes the obfuscation mechanism, documented in Section 5.2 of [RFC5425]. Such a method is weak.

The introduction of TLS PSK, certificate peer authentication, and TLS encryption to TACACS+ replaces these former mechanisms and so obfuscation is hereby obsoleted. This section describes how the TACACS+ client and servers MUST operate with regards to the obfuscation mechanism.

Peers MUST NOT use obfuscation with TLS.

A TACACS+ client initiating a TACACS+ TLS connection MUST set the TAC_PLUS_UNENCRYPTED_FLAG bit, thereby asserting that obfuscation is not used for the session. All subsequent packets MUST have the TAC_PLUS_UNENCRYPTED_FLAG set.

A TLS TACACS+ server that receives a packet with the TAC_PLUS_UNENCRYPTED_FLAG not set (cleared) over a TLS connection, MUST return an error of TAC_PLUS_AUTHEN_STATUS_ERROR, TAC_PLUS_AUTHOR_STATUS_ERROR, or TAC_PLUS_ACCT_STATUS_ERROR as appropriate for the TACACS+ message type, with the TAC_PLUS_UNENCRYPTED_FLAG set, and terminate the session. This behavior corresponds to that defined in Section 4.5 of [RFC8907] Data Obfuscation for TAC_PLUS_UNENCRYPTED_FLAG or key mismatches.

A TACACS+ client that receives a packet with the TAC_PLUS_UNENCRYPTED_FLAG not set (i.e., cleared), MUST terminate the session ~~and, and~~ SHOULD log this error.

5. Security Considerations

5.1. TLS

This document improves the confidentiality, integrity, and authentication of the connection and network traffic between TACACS+ peers by adding TLS support.

Simply adding TLS support to the TACACS+ protocol does not guarantee the protection of the TLS TACACS+ server and clients. It is essential for the operators and equipment vendors to adhere to the latest best practices for ensuring the integrity of network devices and selecting secure TLS key and encryption algorithms.

[BCP195] offers substantial guidance for implementing protocols that use TLS and their deployment. Those implementing and deploying Secure TACACS+ must adhere to the recommendations relevant to TLS 1.3 outlined in [BCP195] or its subsequent versions.

This document outlines additional restrictions permissible under [BCP195] For example, any recommendations referring to TLS 1.2, including the mandatory support, are not relevant for Secure TACACS+ as TLS 1.3 or above is mandated.

This document concerns the use of TLS as transport for TACACS+, and does not make any changes to the core TACACS+ protocol, other than the direct implications of deprecating obfuscation. Operators MUST be cognizant of the security implications of the TACACS+ protocol itself. Further documents are planned, for example, to address the security implications of ~~password-based~~password-based authentication and enhance the protocol to accommodate alternative schemes.

5.1.1. TLS Use

New TACACS+ production deployments SHOULD use TLS authentication and

encryption. Also see [RFC3365].

TLS TACACS+ servers (see definition in Section 2.4) MUST NOT allow Non-TLS connections, because of the threat of downgrade attacks or misconfiguration described in Section 5.3. Instead, separate Non-TLS TACACS+ servers SHOULD be set up to cater for these clients.

It is NOT RECOMMENDED that TLS TACACS+ servers and Non-TLS TACACS+ servers be deployed on the same host, for reasons discussed in Section 5.3. Non-TLS connections would be better served by deploying the required Non-TLS TACACS+ servers on separate hosts.

TACACS+ Clients MUST NOT fail back to a Non-TLS connection if a TLS connection fails. This prohibition includes during the migration of a deployment (see Section 6.1).

5.1.2. TLS 0-RTT

TLS 1.3 resumption and PSK techniques make it possible to send Early Data, aka. 0-RTT data, data that is sent before the TLS handshake completes. Replay of this data is a risk. Given the sensitivity of TACACS+ data, clients MUST NOT send data until the full TLS handshake completes; that is, clients MUST NOT send 0-RTT data and TLS TACACS+ servers MUST abruptly disconnect clients that do.

5.1.3. TLS Options

Recommendations in [BCP195] MUST be followed, in order to determine which TLS versions and algorithms should be supported, deprecated, obsoleted, or abandoned.

Also, Section 9 of [RFC8446] prescribes mandatory supported options.

5.1.4. Unreachable Certification Authority (CA)

Operators should be cognizant of the potential of TLS TACACS+ server and/or client isolation from their peer's CA by network failures. Isolation from a public key certificate's CA will cause the verification of the certificate to fail and thus TLS authentication of the peer to fail. The approach mentioned in Section 3.4.1 can help address this, and should be considered where implemented.

5.1.5. TLS Server Name Indicator (SNI)

Operators should be aware that the TLS SNI extension is part of the TLS ~~ClientHello~~~~client-hello~~, and is, therefore, subject to eavesdropping. Also see Section 11.1 of [RFC6066].

5.2. TACACS+ Configuration

Implementors must ensure that the configuration scheme introduced for enabling TLS is straightforward and leaves no room for ambiguity regarding whether TLS or Non-TLS will be used between the TACACS+ client and the TACACS+ server.

This document recommends the use of a separate port number that TLS TACACS+ servers will listen to. Where deployments have not

overridden the defaults explicitly, TACACS+ client implementations MUST use the ~~correct~~-following values:

- * for Non-TLS connection TACACS+: Port 49.
- * for TLS connection TACACS+: (TBD).

Implementors may offer a single option for TACACS+ clients and servers to disable all Non-TLS TACACS+ operations. When enabled on a TACACS+ server, it will not respond to any requests from Non-TLS TACACS+ client connections. When enabled on a TACACS+ client, it will not establish any Non-TLS TACACS+ server connections.

5.3. Well-Known TCP/IP Port

A new port number is ~~considered~~ appropriate and superior to a "STARTTLS" command or other negotiation method because it allows:

- * ease of blocking the unobfuscated or obfuscated connections by the TCP/IP port number,
- * passive Intrusion Detection Systems (IDSs) monitoring the unobfuscated to be unaffected by the introduction of TLS,
- * avoidance of ~~Man in the Middle (MitM)~~ on-path attacks that can interfere with STARTTLS, and
- * ~~and~~ helps prevent the accidental exposure of sensitive information due to misconfiguration.

However, co-existence of inferior authentication and obfuscated, whether ~~an-a~~ Non-TLS connection or deprecated parts that compose TLS, also presents opportunity for down-grade attacks. Causing failure of connections to the TLS-enabled service or the negotiation of shared algorithm support are two such down-grade attacks.

The simplest way to address exposure from Non-TLS connection methods is to refuse Non-TLS connections at the host entirely, perhaps using separate hosts for Non-TLS connections and TLS.

Another approach is mutual configuration that requires TLS. TACACS+ Clients and servers SHOULD support configuration that requires peers, globally and individually, use TLS. Furthermore, peers SHOULD be configurable to limit offered or recognized TLS versions and algorithms to those recommended by standards bodies and implementers.

6. Operational Considerations

Operational and deployment considerations are spread throughout the document. While avoiding repetition, it is useful for the impatient to direct particular attention to Sections 5.2 and 5.1.5. However, it is important that the entire Section 5 is observed.

6.1. Migration

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In Section 5.2, it is mentioned that for an optimal deployment of TLS TACACS+, TLS should be universally applied throughout the deployment. However, during the migration process from a Non-TLS TACACS+ deployment, operators may need to support both TLS and Non-TLS TACACS+ servers. This migration phase allows operators to gradually transition their deployments from an insecure state to a more secure one, but it is important to note that it is vulnerable to downgrade attacks. Therefore, the migration phase should be considered insecure until it is fully completed. To mitigate this hazard:

- * ~~The~~ period where any client is configured with both TLS and Non-TLS TACACS+ servers should be minimized.
- * ~~the~~ The operator must consider the impact of mixed TLS and Non-TLS on security.

6.2. Maintaining Non-TLS TACACS+ Clients

Some TACACS+ client devices in a deployment may not implement TLS. These devices will require access to Non-TLS TACACS+ servers. Operators must follow the recommendation of Section 5.1.1 and deploy separate Non-TLS TACACS+ servers for these Non-TLS clients from those used for the TLS clients.

6.3. YANG Model for TACACS+ Clients

[ietf-opsawg-secure-tacacs-yang] specifies a YANG model for managing TACACS+ clients, including TLS support.

7. IANA Considerations

The authors request that, when this draft is accepted by the working group, the OPSAWG Chairs submit a request to IANA for an early allocation, per [RFC4020] and [RFC6335], of a new well-known system TCP/IP port number for the service name "tacacss" (referenced in this document also as "TACACS+ TLS well-known port ([TBD])"), described as "TACACS+ over TLS". The service name "tacacss" follows the common practice of appending an "s" to the name given to the Non-TLS well-known port name. This allocation is justified in Section 5.3.

This document requests IANA to add a new entity from the "Service name and Transport Protocol Port Number Registry" available at <https://www.iana.org/assignments/service-names-port-numbers/>

Service Name: tacacss

Port Number: [TBD]

Transport Protocol: TCP

Description: TLS Secure Login Host Protocol (TACACSS)

Assignee: IESG

Contact: IETF Chair

Reference: [TBDN] (This Document)

RFC EDITOR: this port number should replace "[TBD]" and the service name should replace "[TBDN]" within this document.

Considerations about service discovery are out of scope of this document.

8. Acknowledgments

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Commenté [BMI4]: Given that we have «It is RECOMMENDED that systems follow the directions of Section 4 of [RFC8446], and [RFC9257].»

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