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# The TACACS+ Protocol
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## Abstract

TACACS+ provides Device Administration for routers, network access servers and other networked computing devices via one or more centralized servers. This document describes the protocol that is used by TACACS+.

## Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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## 1. Introduction

Terminal Access Controller Access-Control System Plus (TACACS+) was conceived initially as a general Authentication, Authorization and Accounting protocol. It is primarily used today for Device Administration: authenticating access to network devices, providing central authorization of operations, and audit of those operations.

A wide range of TACACS+ clients and servers are already deployed in the field. The TACACS+ protocol they are based on is defined in a draft document that was originally intended for IETF publication. This document is known as 'The Draft' [TheDraft] .

It is intended that all implementations which conform to this document will conform to 'The Draft'. However, attention is drawn to the following specific adjustments of the protocol specification from 'The Draft':

This document officially removes SENDPASS for security reasons.

The normative description of Legacy features such as ARAP and outbound authentication has been removed, however, the required enumerations are kept.

The Support for forwarding to an alternative daemon (TAC_PLUS_AUTHEN_STATUS_FOLLOW) has been deprecated.

The TACACS+ protocol separates the functions of Authentication, Authorization and Accounting. It allows for arbitrary length and content authentication exchanges, to support future authentication mechanisms. It is extensible to provide for site customization and

future development features, and it uses TCP to ensure reliable delivery. The protocol allows the TACACS+ client to request very fine-grained access control and allows the server to respond to each component of that request.

The separation of authentication, authorization and accounting was a key element of the design of TACACS+ protocol. Essentially it makes TACACS+ a suite of three protocols. This document will address each one in separate sections. Although TACACS+ defines all three, but an implementation or configuration is not required to employ all three. Separating the elements is useful for Device Administration use case, specifically, for authorization of individual commands in a session. Note that there is no provision made at the protocol level for association of an authentication to each authorization request.

This document restricts itself to a description of the protocol that is used by TACACS+. It does not cover deployment or best practices.

## 2. Technical Definitions

This section provides a few basic definitions that are applicable to this document

Client

The client is any device, (often a Network Access Server) that provides access services. The clients usually provide a character mode front end and then allow the user to telnet or rlogin to another host.

Server

The server receives TACACS+ protocol requests, and replies according to its business model, in accordance with the flows defined in this document.

Packet

All uses of the word packet in this document refer to TACACS+ protocol packets unless explicitly noted otherwise.

## 3. TACACS+ Connections and Sessions

### 3.1. Connection

TACACS+ uses TCP for its transport. Server port 49 is allocated for TACACS+ traffic.

### 3.2. Session

The concept of a session is used throughout this document. A TACACS+ session is a single authentication sequence, a single authorization exchange, or a single accounting exchange.

An accounting and authorization session will consist of a single pair of packets (the request and its reply). An authentication session may involve an arbitrary number of packets being exchanged. The session is an operational concept that is maintained between the TACACS+ client and server. It does not necessarily correspond to a given user or user action.

### 3.3. Single Connection Mode

Single Connection Mode is intended to improve performance by allowing a client to multiplex multiple session on a single TCP connection.

The packet header contains the TAC_PLUS_SINGLE_CONNECT_FLAG used by the client and server to negotiate the use of Single Connect Mode.

The client sets this flag, to indicate that it supports multiplexing TACACS+ sessions over a single TCP connection. The client MUST NOT send a second packet on a connection until single-connect status has been established.

To indicate it will support Single Connection Mode, the server sets this flag in the first reply packet in response to the first request from a client. The server may set this flag even if the client does not set it, but the client may ignore the flag and close the connection after the session completes.

The flag is only relevant for the first two packets on a connection, to allow the client and server to establish Single Connection Mode. No provision is made for changing Single Connection Mode after the first two packets: the client and server MUST ignore the flag after the second packet on a connection.

If single Connection Mode has not been established in the first two packets of a TCP connection, then both the client and the server close the connection at the end of the first session.

The client negotiates Single Connection Mode to improve efficiency. The server may refuse to allow Single Connection Mode for the client. For example, it may not be appropriate to allocate a long-lasting TCP connection to a specific client in some deployments. Even if the server is configured to permit single Connection Mode for a specific client, the server may close the connection. For example: a server

may be configured to time out a Single Connection Mode TCP Connection after a specific period of inactivity to preserve its resources. The client MUST accommodate such closures on a TCP session even after Single Connection Mode has been established.

## 3.4. Session Completion

The REPLY packets defined for the packets types in the sections below (Authentication, Authorization and Accounting) contain a status field. The complete set of options for this field depend upon the packet type, but all three REPLY packet types define values representing PASS, ERROR and FAIL, which indicate the last packet of a regular session (one which is not aborted).

The server responds with a PASS or a FAIL to indicate that the processing of the request completed and the client can apply the result (PASS or FAIL) to control the execution of the action which prompted the request to be sent to the server.

The server responds with an ERROR to indicate that the processing of the request did not complete. The client can not apply the result and it MUST behave as if the server could not be connected to. For example, the client tries alternative methods, if they are available, such as sending the request to a backup server, or using local configuration to determine whether the action which prompted the request should be executed.

Refer to the section (Section 4.4.3) on Aborting Authentication Sessions for details on handling additional status options.

When the session is complete, then the TCP connection should be handled as follows, according to whether Single Connection Mode was negotiated:

If Single Connection Mode was not negotiated, then the connection should be closed

If Single Connection Mode was enabled, then the connection SHOULD be left open (see section (Section 3.3) ), but may still be closed after a timeout period to preserve deployment resources

If Single Connection Mode was enabled, but an ERROR occurred due to connection issues (such as an incorrect secret, see section (Section 3.7) ), then any further new sessions MUST NOT be accepted on the connection. If there are any sessions that have already been established then they MAY be completed. Once all active sessions are completed then the connection MUST be closed.

It is recommended that client implementations provide robust schemes for dealing with servers which cannot be connected to. Options include providing a list of servers for redundancy, and an option for a local fallback configuration if no servers can be reached. Details will be implementation specific.

The client should manage connections and handle the case of a server which establishes a connection, but does not respond. The exact behavior is implementation specific. It is recommended that the client should close the connection after a configurable timeout.

## 3.5. Treatment of Enumerated Protocol Values

This document describes various enumerated values in the packet header and the headers for specific packet types. For example in the Authentication start packet type, this document defines the action field with three values TAC_PLUS_AUTHEN_LOGIN, TAC_PLUS_AUTHEN_CHPASS and TAC_PLUS_AUTHEN_SENDAUTH.

If the server does not implement one of the defined options in a packet that it receives, or it encounters an option that is not listed in this document for a header field, then it should respond with a ERROR and terminate the session. This will allow the client to try a different option.

If an error occurs but the type of the incoming packet cannot be determined, a packet with the identical cleartext header but with a sequence number incremented by one and the length set to zero MUST be returned to indicate an error.

## 3.6. Text Encoding

All text fields in TACACS+ MUST be printable US-ASCII, excepting special consideration given to user field and data fields used for passwords.

To ensure interoperability of current deployments, the TACACS+ client and server MUST handle user fields and those data fields used for passwords as 8-bit octet strings. The deployment operator MUST ensure that consistent character encoding is applied from the end client to the server. The encoding SHOULD be UTF-8, and other encodings outside printable US-ASCII SHOULD be deprecated.

## 3.7. Data Obfuscation

The body of packets may be obfuscated. The following sections describe the obfuscation method that is supported in the protocol. In 'The Draft' this process was actually referred to as Encryption,

but the algorithm would not meet modern standards, and so will not be termed as encryption in this document.

The obfuscation mechanism relies on a secret key, a shared secret value that is known to both the client and the server. This document does not discuss the management and storage of those keys, other than to require that the secret keys MUST remain secret.

Server implementations MUST allow a unique secret key to be associated with every client. It is a site-dependent decision as to whether the use of separate keys is appropriate.

The flag field may be set as follows:

TAC_PLUS_UNENCRYPTED_FLAG = 0x0

In this case, the packet body is obfuscated by XOR-ing it byte-wise with a pseudo-random pad.

ENCRYPTED {data} = data ^ pseudo_pad

The packet body can then be de-obfuscated by XOR-ing it byte-wise with a pseudo random pad.

data = ENCRYPTED {data} ^ pseudo_pad

The pad is generated by concatenating a series of MD5 hashes (each 16 bytes long) and truncating it to the length of the input data.

Whenever used in this document, MD5 refers to the "RSA Data Security, Inc. MD5 Message-Digest Algorithm" as specified in RFC 1321 [RFC1321] .

pseudo_pad = {MD5_1 [,MD5_2 [ ... ,MD5_n]]} truncated to len(data)

The first MD5 hash is generated by concatenating the session_id, the secret key, the version number and the sequence number and then running MD5 over that stream. All of those input values are available in the packet header, except for the secret key which is a shared secret between the TACACS+ client and server.

The version number and session_id are used as extracted from the header

Subsequent hashes are generated by using the same input stream, but concatenating the previous hash value at the end of the input stream.

MD5_1 = MD5{session_id, key, version, seq_no} MD5_2 = MD5{session_id, key, version, seq_no, MD5_1} .... MD5_n = MD5{session_id, key, version, seq_no, MD5_n-1}

When a server detects that the secret(s) it has configured for the device mismatch, it MUST return ERROR. For details of TCP connection handling on ERROR, refer to section (Section 3.4)

TAC_PLUS_UNENCRYPTED_FLAG == 0x1

In this case, the entire packet body is in cleartext. Obfuscation and de-obfuscation are null operations. This method should be avoided unless absolutely required for debug purposes, when tooling does not permit de-obfuscation.

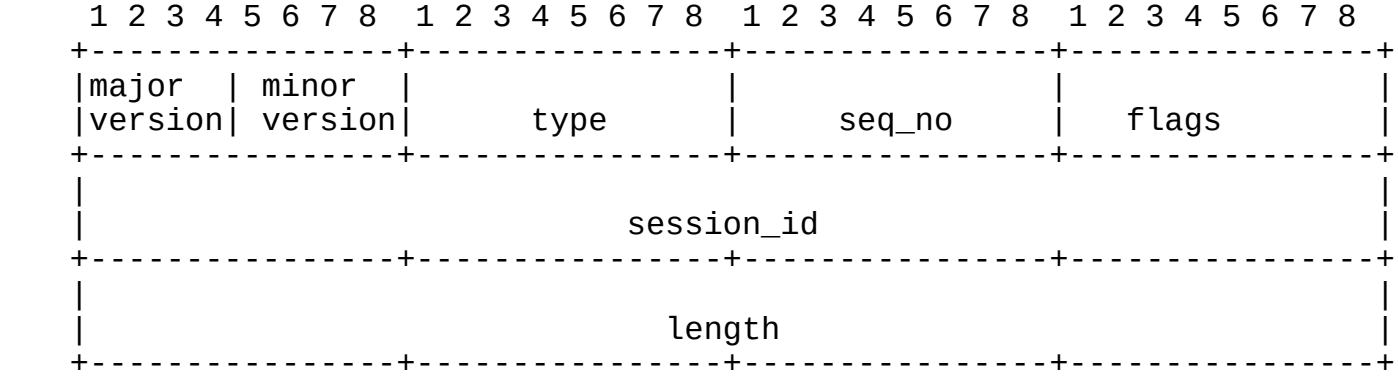
If deployment is configured for obfuscating a connection then the request MUST be dropped if TAC_PLUS_UNENCRYPTED_FLAG is set to true.

After a packet body is de-obfuscated, the lengths of the component values in the packet are summed. If the sum is not identical to the cleartext datalength value from the header, the packet MUST be discarded, and an ERROR signaled. For details of TCP connection handling on ERROR, refer to section (Section 3.4)

Commonly such failures are seen when the keys are mismatched between the client and the TACACS+ server.

## 3.8. The TACACS+ Packet Header

All TACACS+ packets begin with the following 12-byte header. The header describes the remainder of the packet:




major_version

This is the major TACACS+ version number.

TAC_PLUS_MAJOR_VER := 0xc

minor_version

The minor TACACS+ version number.

TAC_PLUS_MINOR_VER_DEFAULT := 0x0

TAC_PLUS_MINOR_VER_ONE := 0x1

type

This is the packet type. Legal values are:

TAC_PLUS_AUTHEN := 0x01 (Authentication)

TAC_PLUS_AUTHOR := 0x02 (Authorization)

TAC_PLUS_ACCT := 0x03 (Accounting)

seq_no

This is the sequence number of the current packet. The first packet in a session MUST have the sequence number 1 and each subsequent packet will increment the sequence number by one. Thus clients only send packets containing odd sequence numbers, and TACACS+ servers only send packets containing even sequence numbers.

The sequence number must never wrap i.e. if the sequence number 2^8-1 is ever reached, that session must terminate and be restarted with a sequence number of 1.

flags

This field contains various bitmapped flags.

The flag bit:

TAC_PLUS_UNENCRYPTED_FLAG := 0x01

This flag indicates that the sender did not obfuscate the body of the packet. The application of this flag will be covered in the security section (Section 9) .

This flag SHOULD be clear in all deployments. Modern network traffic tools support encrypted traffic when configured with the shared secret (see section below), so obfuscated mode can and SHOULD be used even during test.

The single-connection flag:

TAC_PLUS_SINGLE_CONNECT_FLAG := 0x04

This flag is used to allow a client and server to negotiate Single Connection Mode.

session_id

The Id for this TACACS+ session. This field does not change for the duration of the TACACS+ session. This number MUST be generated by a cryptographically strong random number generation method. Failure to do so will compromise security of the session. For more details refer to RFC 1750 [RFC1750]

length

The total length of the packet body (not including the header).

## 3.9. The TACACS+ Packet Body

The TACACS+ body types are defined in the packet header. The next sections of this document will address the contents of the different TACACS+ bodies. The following general rules apply to all TACACS+ body types:

- To signal that any variable length data fields are unused, their length value is set to zero. Such fields MUST be ignored, and treated as if not present.

- the lengths of data and message fields in a packet are specified by their corresponding length fields, (and are not null terminated.)

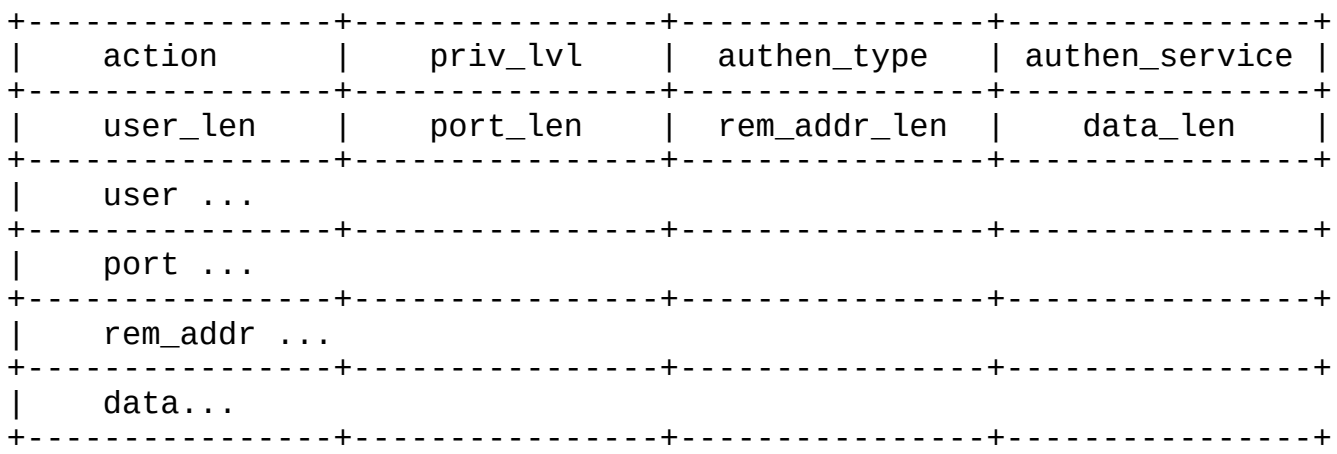
- All length values are unsigned and in network byte order.

# 4. Authentication

Authentication is the action of determining who a user (or entity) is. Authentication can take many forms. Traditional authentication employs a name and a fixed password. However, fixed passwords are vulnerable security, so many modern authentication mechanisms utilize "one-time" passwords or a challenge-response query. TACACS+ is designed to support all of these, and be flexible enough to handle any future mechanisms. Authentication generally takes place when the user first logs in to a machine or requests a service of it.

Authentication is not mandatory; it is a site-configured option. Some sites do not require it. Others require it only for certain services (see authorization below). Authentication may also take place when a user attempts to gain extra privileges, and must identify himself or herself as someone who possesses the required information (passwords, etc.) for those privileges.

## 4.1. The Authentication START Packet Body




Packet fields are as follows:

action

This indicates the authentication action. Legal values are listed below.

TAC_PLUS_AUTHEN_LOGIN := 0x01

TAC_PLUS_AUTHEN_CHPASS := 0x02

TAC_PLUS_AUTHEN_SENDAUTH := 0x04

priv_lvl

This indicates the privilege level that the user is authenticating as. Please refer to the Privilege Level section (Section 8) below.

authen_type

The type of authentication. Legal values are:

TAC_PLUS_AUTHEN_TYPE_ASCII := 0x01

TAC_PLUS_AUTHEN_TYPE_PAP := 0x02

TAC_PLUS_AUTHEN_TYPE_CHAP := 0x03

TAC_PLUS_AUTHEN_TYPE_ARAP := 0x04 (deprecated)

TAC_PLUS_AUTHEN_TYPE_MSCHAP := 0x05

TAC_PLUS_AUTHEN_TYPE_MSCHAPV2 := 0x06

authen_service

This is the service that is requesting the authentication. Legal values are:

TAC_PLUS_AUTHEN_SVC_NONE := 0x00

TAC_PLUS_AUTHEN_SVC_LOGIN := 0x01

TAC_PLUS_AUTHEN_SVC_ENABLE := 0x02

TAC_PLUS_AUTHEN_SVC_PPP := 0x03

TAC_PLUS_AUTHEN_SVC_ARAP := 0x04

TAC_PLUS_AUTHEN_SVC_PT := 0x05

TAC_PLUS_AUTHEN_SVC_RCMD := 0x06

TAC_PLUS_AUTHEN_SVC_X25 := 0x07

TAC_PLUS_AUTHEN_SVC_NASI := 0x08

TAC_PLUS_AUTHEN_SVC_FWPROXY := 0x09

The TAC_PLUS_AUTHEN_SVC_NONE option is intended for the authorization application of this field that indicates that no authentication was performed by the device.

The TAC_PLUS_AUTHEN_SVC_LOGIN option indicates regular login (as opposed to ENABLE) to a client device.

The TAC_PLUS_AUTHEN_SVC_ENABLE option identifies the ENABLE authen_service, which refers to a service requesting authentication in order to grant the user different privileges. This is comparable to the Unix "su(1)" command, which substitutes the current user’s identity with another. An authen_service value of NONE is only to be used when none of the other authen_service values are appropriate.

ENABLE may be requested independently, no requirements for previous authentications or authorizations are imposed by the protocol.

Other options are included for legacy/backwards compatibility.

user, user_len

The username is optional in this packet, depending upon the class of authentication. If it is absent, the client MUST set user_len to 0. If included, the user_len indicates the length of the user field, in bytes.

port, port_len

The printable US-ASCII name of the client port on which the authentication is taking place, and its length in bytes. The value of this field is client specific. (For example, Cisco uses "tty10" to denote the tenth tty line and "Async10" to denote the tenth async interface). The port_len indicates the length of the port field, in bytes.

rem_addr, rem_addr_len

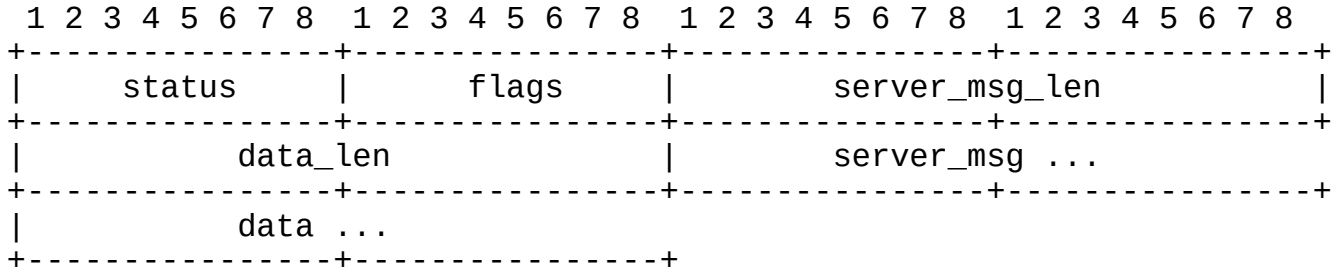
A printable US-ASCII string indicating the remote location from which the user has connected to the client. It is intended to hold a network address if the user is connected via a network, a caller ID is the user is connected via ISDN or a POTS, or any other remote location information that is available. This field is optional (since the information may not be available). The rem_addr_len indicates the length of the user field, in bytes.

data, data_len

This field is used to send data appropriate for the action and authen_type. It is described in more detail in the section Common Authentication flows (Section 4.4.2) . The data_len indicates the length of the data field, in bytes.

## 4.2. The Authentication REPLY Packet Body

The TACACS+ server sends only one type of authentication packet (a REPLY packet) to the client.




status

The current status of the authentication. Legal values are:

TAC_PLUS_AUTHEN_STATUS_PASS := 0x01

TAC_PLUS_AUTHEN_STATUS_FAIL := 0x02

TAC_PLUS_AUTHEN_STATUS_GETDATA := 0x03

TAC_PLUS_AUTHEN_STATUS_GETUSER := 0x04

TAC_PLUS_AUTHEN_STATUS_GETPASS := 0x05

TAC_PLUS_AUTHEN_STATUS_RESTART := 0x06

TAC_PLUS_AUTHEN_STATUS_ERROR := 0x07

TAC_PLUS_AUTHEN_STATUS_FOLLOW := 0x21

flags

Bitmapped flags that modify the action to be taken. The following values are defined:

TAC_PLUS_REPLY_FLAG_NOECHO := 0x01

server_msg, server_msg_len

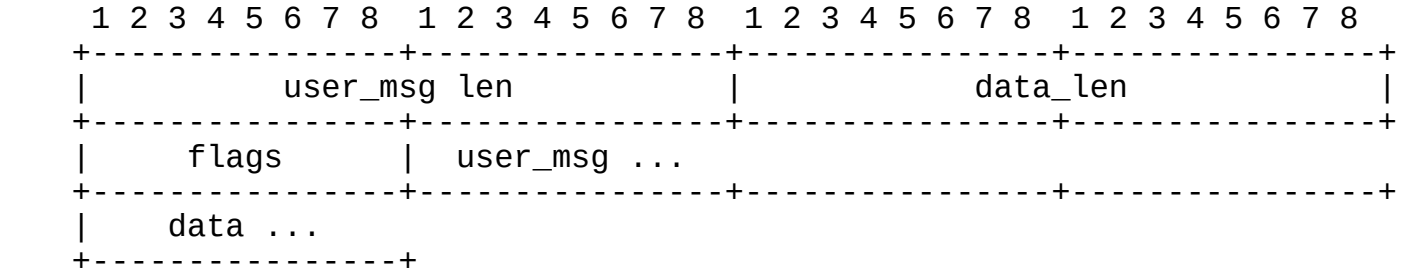
A message to be displayed to the user. This field is optional. The printable US-ASCII charset MUST be used. The server_msg_len indicates the length of the server_msg field, in bytes.

data, data_len

This field holds data that is a part of the authentication exchange and is intended for the client, not the user. Examples of its use are shown in the section Common Authentication flows (Section 4.4.2) . The data_len indicates the length of the data field, in bytes.

## 4.3. The Authentication CONTINUE Packet Body

This packet is sent from the client to the server following the receipt of a REPLY packet.




user_msg, user_msg_len

This field is the string that the user entered, or the client provided on behalf of the user, in response to the server_msg from a REPLY packet. The user_len indicates the length of the user field, in bytes.

data, data_len

This field carries information that is specific to the action and the authen_type for this session. Valid uses of this field are described below. The data_len indicates the length of the data field, in bytes.

flags

This holds the bitmapped flags that modify the action to be taken. The following values are defined:

```
TAC_PLUS_CONTINUE_FLAG_ABORT := 0x01
```

## 4.4. Description of Authentication Process

The action, authen_type and authen_service fields (described above) combine to indicate what kind of authentication is to be performed. Every authentication START, REPLY and CONTINUE packet includes a data field. The use of this field is dependent upon the kind of the Authentication.

This document defines a core set of authentication flows to be supported by TACACS+. Each authentication flow consists of a START packet. The server responds either with a request for more information (GETDATA, GETUSER or GETPASS) or a termination PASS,

FAIL, ERROR or RESTART. The actions and meanings when the server sends a RESTART or ERROR are common and are described further below.

When the REPLY status equals TAC_PLUS_AUTHEN_STATUS_GETDATA, TAC_PLUS_AUTHEN_STATUS_GETUSER or TAC_PLUS_AUTHEN_STATUS_GETPASS, then authentication continues and the server SHOULD provide server_msg content for the client to prompt the user for more information. The client MUST then return a CONTINUE packet containing the requested information in the user_msg field.

The client should interpret TAC_PLUS_AUTHEN_STATUS_GETUSER as a request for username and TAC_PLUS_AUTHEN_STATUS_GETPASS as a request for password. The TAC_PLUS_AUTHEN_STATUS_GETDATA is the generic request for more information to flexibly support future requirements.

If the information being requested by the server form the client is sensitive, then the server should set the TAC_PLUS_REPLY_FLAG_NOECHO flag. When the client queries the user for the information, the response MUST NOT be echoed as it is entered.

The data field is only used in the REPLY where explicitly defined below.

#### 4.4.1. Version Behaviour

The TACACS+ protocol is versioned to allow revisions while maintaining backwards compatibility. The version number is in every packet header. The changes between minor_version 0 and 1 apply only to the authentication process, and all deal with the way that CHAP and PAP authentications are handled. minor_version 1 may only be used for authentication kinds that explicitly call for it in the table below:

| | LOGIN | CHPASS | SENDAUTH |
|---|---|---|---|
| ASCII | v0 | v0 | - |
| PAP | v1 | - | v1 |
| CHAP | v1 | - | v1 |
| MS-CHAPv1/2 | v1 | - | v1 |

The ’-’ symbol represents that the option is not valid.

All authorisation and accounting and ASCII authentication use minor_version number of 0.

PAP, CHAP and MS-CHAP login use minor_version 1. The normal exchange is a single START packet from the client and a single REPLY from the server.

The removal of SENDPASS was prompted by security concerns, and is no longer considered part of the TACACS+ protocol.

#### 4.4.2. Common Authentication Flows

This section describes common authentication flows. If the server does not implement an option, it MUST respond with TAC_PLUS_AUTHEN_STATUS_FAIL.

##### 4.4.2.1. ASCII Login

```
action = TAC_PLUS_AUTHEN_LOGIN
authen_type = TAC_PLUS_AUTHEN_TYPE_ASCII
minor_version = 0x0
```

This is a standard ASCII authentication. The START packet MAY contain the username. If the user does not include the username then the server MUST obtain it from the client with a CONTINUE TAC_PLUS_AUTHEN_STATUS_GETUSER. If the user does not provide a username then the server can send another TAC_PLUS_AUTHEN_STATUS_GETUSER request, but the server MUST limit the number of retries that are permitted, recommended limit is three attempts. When the server has the username, it will obtain the password using a continue with TAC_PLUS_AUTHEN_STATUS_GETPASS. ASCII login uses the user_msg field for both the username and password. The data fields in both the START and CONTINUE packets are not used for ASCII logins, any content MUST be ignored. The session is composed of a single START followed by zero or more pairs of REPLYs and CONTINUEs, followed by a final REPLY indicating PASS, FAIL or ERROR.

##### 4.4.2.2. PAP Login

```
action = TAC_PLUS_AUTHEN_LOGIN
authen_type = TAC_PLUS_AUTHEN_TYPE_PAP
minor_version = 0x1
```

The entire exchange MUST consist of a single START packet and a single REPLY. The START packet MUST contain a username and the data field MUST contain the PAP ASCII password. A PAP authentication only consists of a username and password RFC 1334 [RFC1334] . The REPLY from the server MUST be either a PASS, FAIL or ERROR.

#### 4.4.2.3. CHAP login

```
action = TAC_PLUS_AUTHEN_LOGIN
authen_type = TAC_PLUS_AUTHEN_TYPE_CHAP
minor_version = 0x1
```

The entire exchange MUST consist of a single START packet and a single REPLY. The START packet MUST contain the username in the user field and the data field is a concatenation of the PPP id, the challenge and the response.

The length of the challenge value can be determined from the length of the data field minus the length of the id (always 1 octet) and the length of the response field (always 16 octets).

To perform the authentication, the server calculates the PPP hash as defined in the PPP Authentication RFC RFC 1334 [RFC1334] and then compare that value with the response. The MD5 algorithm option is always used. The REPLY from the server MUST be a PASS, FAIL or ERROR.

The selection of the challenge and its length are not an aspect of the TACACS+ protocol. However, it is strongly recommended that the client/endstation interaction is configured with a secure challenge. The TACACS+ server can help by rejecting authentications where the challenge is below a minimum length (Minimum recommended is 8 bytes).

#### 4.4.2.4. MS-CHAP v1 login

```
action = TAC_PLUS_AUTHEN_LOGIN
authen_type = TAC_PLUS_AUTHEN_TYPE_MSCHAP
minor_version = 0x1
```

The entire exchange MUST consist of a single START packet and a single REPLY. The START packet MUST contain the username in the user field and the data field will be a concatenation of the PPP id, the MS-CHAP challenge and the MS-CHAP response.

The length of the challenge value can be determined from the length of the data field minus the length of the id (always 1 octet) and the length of the response field (always 49 octets).

To perform the authentication, the server will use a combination of MD4 and DES on the user’s secret and the challenge, as defined in RFC 2433 [RFC2433] and then compare the resulting value with the response. The REPLY from the server MUST be a PASS or FAIL.

For best practices, please refer to RFC 2433 [RFC2433] . The TACACS+ server MUST reject authentications where the challenge deviates from 8 bytes as defined in the RFC.

#### 4.4.2.5. MS-CHAP v2 login

```
action = TAC_PLUS_AUTHEN_LOGIN
authen_type = TAC_PLUS_AUTHEN_TYPE_MSCHAPV2
minor_version = 0x1
```

The entire exchange MUST consist of a single START packet and a single REPLY. The START packet MUST contain the username in the user field and the data field will be a concatenation of the PPP id, the MS-CHAP challenge and the MS-CHAP response.

The length of the challenge value can be determined from the length of the data field minus the length of the id (always 1 octet) and the length of the response field (always 49 octets).

To perform the authentication, the server will use the algorithm specified RFC 2759 [RFC2759] on the user's secret and challenge and then compare the resulting value with the response. The REPLY from the server MUST be a PASS or FAIL.

For best practices for MS-CHAP v2, please refer to RFC2759 [RFC2759] . The TACACS+ server MUST rejects authentications where the challenge deviates from 16 bytes as defined in the RFC.

#### 4.4.2.6. Enable Requests

```
action = TAC_PLUS_AUTHEN_LOGIN
priv_lvl = implementation dependent
authen_type = not used
service = TAC_PLUS_AUTHEN_SVC_ENABLE
```

This is an ENABLE request, used to change the current running privilege level of a user. The exchange MAY consist of multiple messages while the server collects the information it requires in order to allow changing the principal's privilege level. This exchange is very similar to an ASCII login (Section 4.4.2.1) .

In order to readily distinguish enable requests from other types of request, the value of the authen_service field MUST be set to TAC_PLUS_AUTHEN_SVC_ENABLE when requesting an ENABLE. It MUST NOT be set to this value when requesting any other operation.

#### 4.4.2.7. ASCII change password request

```
action = TAC_PLUS_AUTHEN_CHPASS
authen_type = TAC_PLUS_AUTHEN_TYPE_ASCII
```

This exchange consists of multiple messages while the server collects the information it requires in order to change the user's password. It is very similar to an ASCII login. The status value TAC_PLUS_AUTHEN_STATUS_GETPASS MUST only be used when requesting the "new" password. It MAY be sent multiple times. When requesting the "old" password, the status value MUST be set to TAC_PLUS_AUTHEN_STATUS_GETDATA.

### 4.4.3. Aborting an Authentication Session

The client may prematurely terminate a session by setting the TAC_PLUS_CONTINUE_FLAG_ABORT flag in the CONTINUE message. If this flag is set, the data portion of the message may contain an ASCII message explaining the reason for the abort. This information will be handled by the server according to the requirements of the deployment. The session is terminated, for more details about session termination, refer to section (Section 3.4)

In the case of PALL, FAIL or ERROR, the server can insert a message into server_msg to be displayed to the user.

The Draft 'The Draft' [TheDraft] defined a mechanism to direct authentication requests to an alternative server. This mechanism is regarded as insecure, is deprecated, and not covered here. The client should treat TAC_PLUS_AUTHEN_STATUS_FOLLOW as TAC_PLUS_AUTHEN_STATUS_FAIL

If the status equals TAC_PLUS_AUTHEN_STATUS_ERROR, then the host is indicating that it is experiencing an unrecoverable error and the authentication will proceed as if that host could not be contacted. The data field may contain a message to be printed on an administrative console or log.

If the status equals TAC_PLUS_AUTHEN_STATUS_RESTART, then the authentication sequence is restarted with a new START packet from the client, with new session Id, and seq_no set to 1. This REPLY packet indicates that the current authen_type value (as specified in the START packet) is not acceptable for this session. The client may try an alternative authen_type.

If a client does not implement TAC_PLUS_AUTHEN_STATUS_RESTART option, then it MUST process the response as if the status was TAC_PLUS_AUTHEN_STATUS_FAIL.

# 5. Authorization

In the TACACS+ Protocol, authorization is the action of determining what a user is allowed to do. Generally authentication precedes authorization, though it is not mandatory that a client use the same service for authentication that it will use for authorization. An authorization request may indicate that the user is not authenticated (we don’t know who they are). In this case it is up to the server to determine, according to its configuration, if an unauthenticated user is allowed the services in question.

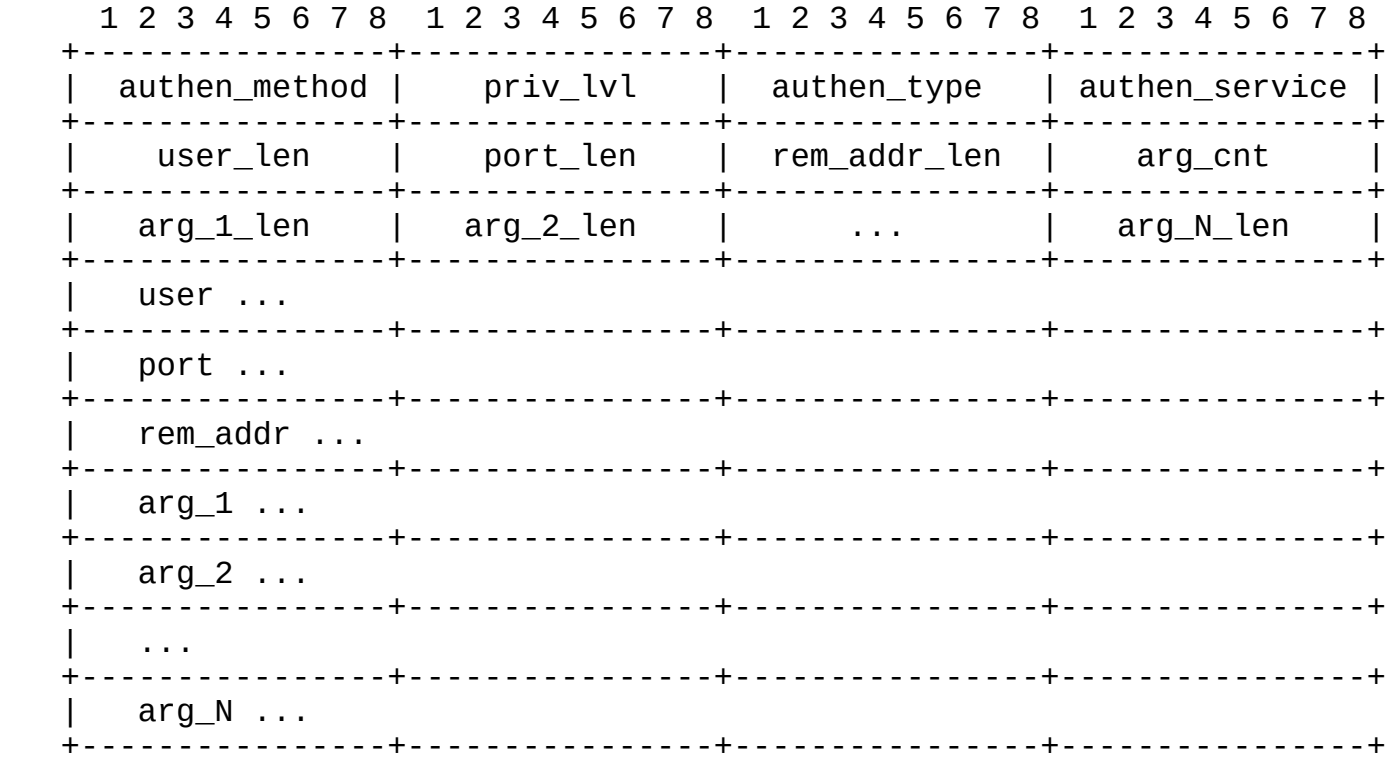
Authorization does not merely provide yes or no answers, but it may also customize the service for the particular user. A common use of authorization is to provision a shell session when a user first logs into a device to administer it. The TACACS+ server might respond to the request by allowing the service, but placing a time restriction on the login shell. For a list of common attributes used in authorization, see the Authorization Attributes section (Section 7.2) .

In the TACACS+ protocol an authorization is always a single pair of messages: a REQUEST from the client followed by a REPLY from the server.

The authorization REQUEST message contains a fixed set of fields that indicate how the user was authenticated and a variable set of arguments that describe the services and options for which authorization is requested.

The REPLY contains a variable set of response arguments (attribute-value pairs) that can restrict or modify the client’s actions.

## 5.1. The Authorization REQUEST Packet Body




authen_method

This indicates the authentication method used by the client to acquire the user information. As this information is not always subject to verification, it is recommended that this field is ignored.

TAC_PLUS_AUTHEN_METH_NOT_SET := 0x00

TAC_PLUS_AUTHEN_METH_NONE := 0x01

TAC_PLUS_AUTHEN_METH_KRB5 := 0x02

TAC_PLUS_AUTHEN_METH_LINE := 0x03

TAC_PLUS_AUTHEN_METH_ENABLE := 0x04

TAC_PLUS_AUTHEN_METH_LOCAL := 0x05

TAC_PLUS_AUTHEN_METH_TACACSPLUS := 0x06

TAC_PLUS_AUTHEN_METH_GUEST := 0x08

TAC_PLUS_AUTHEN_METH_RADIUS := 0x10

TAC_PLUS_AUTHEN_METH_KRB4 := 0x11

TAC_PLUS_AUTHEN_METH_RCMD := 0x20

KRB5 and KRB4 are Kerberos version 5 and 4. LINE refers to a fixed password associated with the terminal line used to gain access. LOCAL is a client local user database. ENABLE is a command that authenticates in order to grant new privileges. TACACSPLUS is, of course, TACACS+. GUEST is an unqualified guest authentication, such as an ARAP guest login. RADIUS is the Radius authentication protocol. RCMD refers to authentication provided via the R-command protocols from Berkeley Unix.

priv_lvl

This field is used in the same way as the priv_lvl field in authentication request and is described in the Privilege Level section (Section 8) below. It indicates the users current privilege level.

authen_type

This field coresponds to the authen_type field in the authentication section (Section 4) above. It indicates the type of authentication that was performed. If this information is not available, then the client will set authen_type to: TAC_PLUS_AUTHEN_TYPE_NOT_SET := 0x00. This value is valid only in authorization and accounting requests.

authen_service

This field is the same as the authen_service field in the authentication section (Section 4) above. It indicates the service through which the user authenticated.

user, user_len

This field contains the user’s account name. The user_len MUST indicate the length of the user field, in bytes.

port, port_len

This field matches the port field in the authentication section (Section 4) above. The port_len indicates the length of the port field, in bytes.

rem_addr, rem_addr_len

This field matches the rem_addr field in the authentication section (Section 4) above. The rem_addr_len indicates the length of the port field, in bytes.

arg_cnt

The number of authorization arguments to follow

arg_1 ... arg_N, arg_1_len .... arg_N_len

The arguments are the primary elements of the authorization interaction. In the request packet they describe the specifics of the authorization that is being requested. Each argument is encoded in the packet as a single arg filed (arg_1... arg_N) with a corresponding length fields (which indicates the length of each argument in bytes).

The authorization arguments in both the REQUEST and the REPLY are attribute-value pairs. The attribute and the value are in a single printable US-ASCII string and are separated by either a "=" (0X3D) or a "*" (0X2A). The equals sign indicates a mandatory argument. The asterisk indicates an optional one.

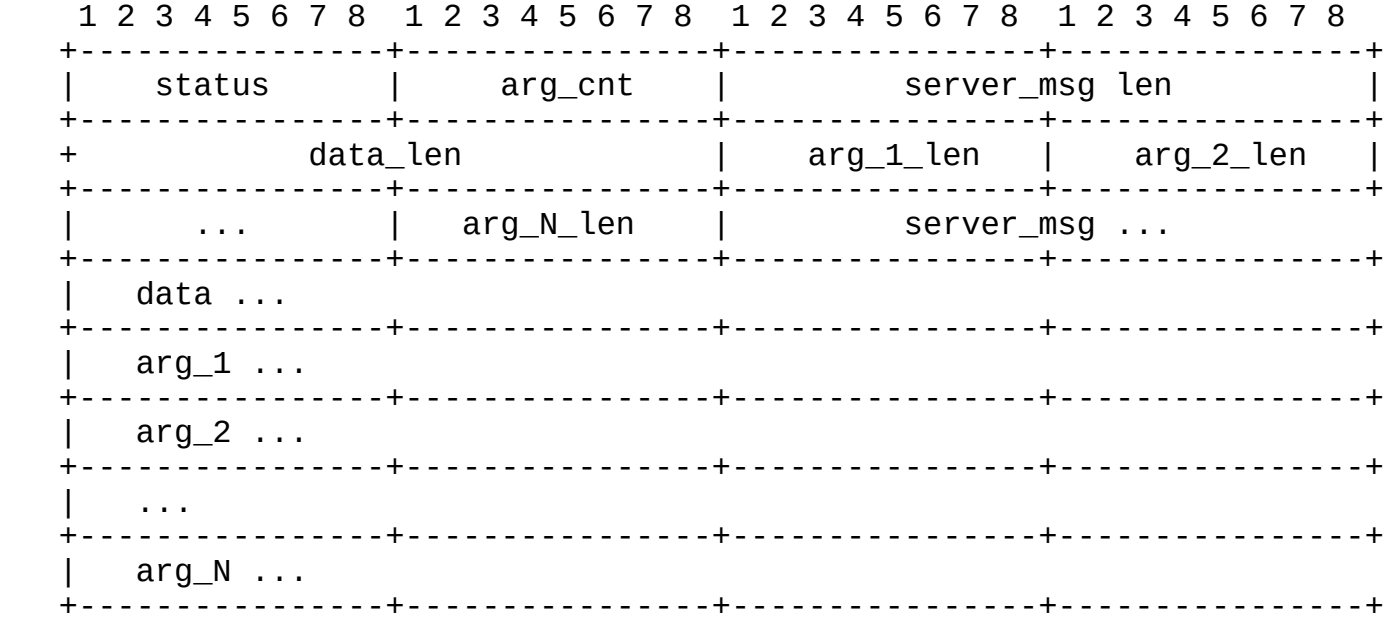
It is not legal for an attribute name to contain either of the separators. It is legal for attribute values to contain the separators. This means that the arguments must be parsed until the first separator is encountered, all characters in the argument, after this separator, are interpreted as the argument value.

Optional arguments are ones that may be disregarded by either client or server. Mandatory arguments require that the receiving side can handle the attribute, that is: its implementation and configuration includes the details of how to act on it. If the client receives a mandatory argument that it cannot handle, it MUST consider the authorization to have failed. It is legal to send an attribute-value pair with a zero length value.

Attribute-value strings are not NULL terminated, rather their length value indicates their end. The maximum length of an attribute-value string is 255 characters. The minimum is two characters (one name-value character and the separator)

Though the attributes allow extensibility, a common core set of authorization attributes SHOULD be supported by clients and servers, these are listed in the Authorization Attributes (Section 7.2) section below.

## 5.2. The Authorization REPLY Packet Body




status This field indicates the authorization status

TAC_PLUS_AUTHOR_STATUS_PASS_ADD := 0x01

TAC_PLUS_AUTHOR_STATUS_PASS_REPL := 0x02

TAC_PLUS_AUTHOR_STATUS_FAIL := 0x10

TAC_PLUS_AUTHOR_STATUS_ERROR := 0x11

TAC_PLUS_AUTHOR_STATUS_FOLLOW := 0x21

server_msg, server_msg_len

This is a printable US-ASCII string that may be presented to the user. The server_msg_len indicates the length of the server_msg field, in bytes.

data, data_len

This is a printable US-ASCII string that may be presented on an administrative display, console or log. The decision to present this message is client specific. The data_len indicates the length of the data field, in bytes.

arg_cnt

The number of authorization arguments to follow.

arg_1 ... arg_N, arg_1_len .... arg_N_len

The arguments describe the specifics of the authorization that is being requested. For details of the content of the args, refer to: Authorization Attributes (Section 7.2) section below. Each argument is encoded in the packet as a single arg field (arg_1... arg_N) with a corresponding length fields (which indicates the length of each argument in bytes).

If the status equals TAC_PLUS_AUTHOR_STATUS_FAIL, then the requested authorization MUST be denied.

If the status equals TAC_PLUS_AUTHOR_STATUS_PASS_ADD, then the arguments specified in the request are authorized and the arguments in the response MUST be applied according to the rules described above.

If the status equals TAC_PLUS_AUTHOR_STATUS_PASS_REPL then the client MUST use the authorization attribute-value pairs (if any) in the response, instead of the authorization attribute-value pairs from the request.

To approve the authorization with no modifications, the server sets the status to TAC_PLUS_AUTHOR_STATUS_PASS_ADD and the arg_cnt to 0.

A status of TAC_PLUS_AUTHOR_STATUS_ERROR indicates an error occurred on the server. For the differences between ERROR and FAIL, refer to section Session Completion (Section 3.4) . None of the arg values have any relevance if an ERROR is set, and must be ignored.

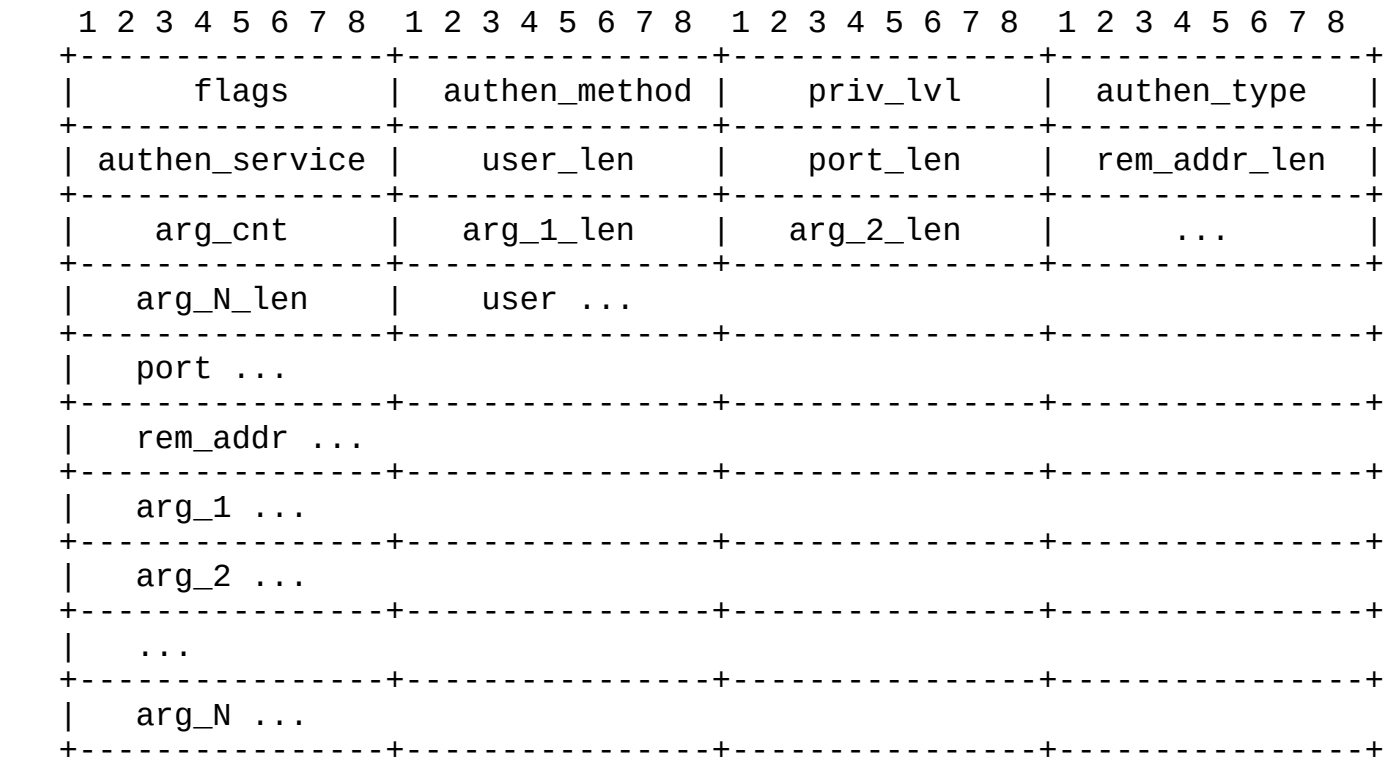
When the status equals TAC_PLUS_AUTHOR_STATUS_FOLLOW, then the arg_cnt MUST be 0. In that case, the actions to be taken and the contents of the data field are identical to the TAC_PLUS_AUTHEN_STATUS_FOLLOW status for Authentication.

# 6. Accounting

Accounting is typically the third action after authentication and authorization. But again, neither authentication nor authorization is required. Accounting is the action of recording what a user is doing, and/or has done. Accounting in TACACS+ can serve two purposes: It may be used as an auditing tool for security services. It may also be used to account for services used, such as in a billing environment. To this end, TACACS+ supports three types of accounting records. Start records indicate that a service is about to begin. Stop records indicate that a service has just terminated,

and Update records are intermediate notices that indicate that a service is still being performed. TACACS+ accounting records contain all the information used in the authorization records, and also contain accounting specific information such as start and stop times (when appropriate) and resource usage information. A list of accounting attributes is defined in the accounting section (Section 6) .

## 6.1. The Account REQUEST Packet Body




flags

This holds bitmapped flags.

TAC_PLUS_ACCT_FLAG_START := 0x02

TAC_PLUS_ACCT_FLAG_STOP := 0x04

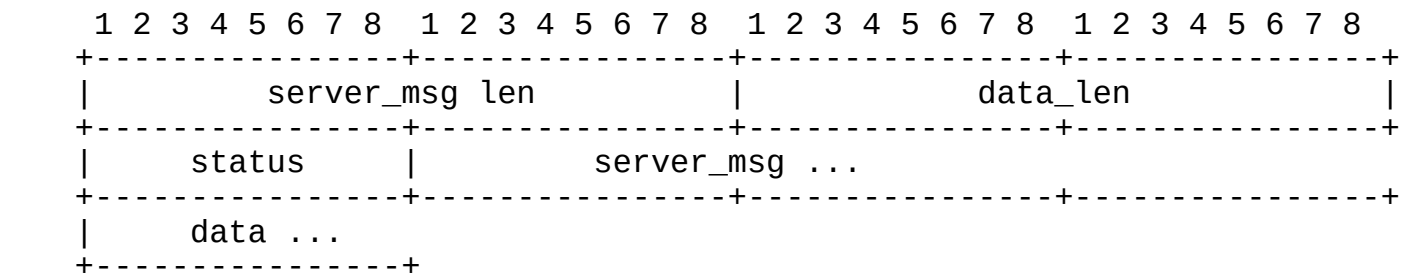
TAC_PLUS_ACCT_FLAG_WATCHDOG := 0x08

All other fields are defined in the authorization and authentication sections above and have the same semantics. They provide details for the conditions on the client, and authentication context, so that these details may be logged for accounting purposes.

See section 12 Accounting Attribute-value Pairs for the dictionary of attributes relevant to accounting.

## 6.2. The Accounting REPLY Packet Body

The purpose of accounting is to record the action that has occurred on the client. The server MUST reply with success only when the accounting request has been recorded. If the server did not record the accounting request then it MUST reply with ERROR.




status

This is the return status. Values are:

TAC_PLUS_ACCT_STATUS_SUCCESS := 0x01

TAC_PLUS_ACCT_STATUS_ERROR := 0x02

TAC_PLUS_ACCT_STATUS_FOLLOW := 0x21

server_msg, server_msg_len

This is a printable US-ASCII string that may be presented to the user. The server_msg_len indicates the length of the server_msg field, in bytes.

data, data_len

This is a printable US-ASCII string that may be presented on an administrative display, console or log. The decision to present this message is client specific. The data_len indicates the length of the data field, in bytes.

When the status equals TAC_PLUS_ACCT_STATUS_FOLLOW, then the actions to be taken and the contents of the data field are identical to the TAC_PLUS_AUTHEN_STATUS_FOLLOW status for Authentication.

TACACS+ accounting is intended to record various types of events on clients, for example: login sessions, command entry, and others as

required by the client implementation. These events are collectively referred to in ‘The Draft’ [TheDraft] as "tasks".

The TAC_PLUS_ACCT_FLAG_START flag indicates that this is a start accounting message. Start messages will only be sent once when a task is started. The TAC_PLUS_ACCT_FLAG_STOP indicates that this is a stop record and that the task has terminated. The TAC_PLUS_ACCT_FLAG_WATCHDOG flag means that this is an update record.

Summary of Accounting Packets

| Watchdog | Stop | Start | Flags & 0xE | Meaning |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | INVALID |
| 0 | 0 | 1 | 2 | Start Accounting Record |
| 0 | 1 | 0 | 4 | Stop Accounting Record |
| 0 | 1 | 1 | 6 | INVALID |
| 1 | 0 | 0 | 8 | Watchdog, no update |
| 1 | 0 | 1 | A | Watchdog, with update |
| 1 | 1 | 0 | C | INVALID |
| 1 | 1 | 1 | E | INVALID |

The START and STOP flags are mutually exclusive.

The WATCHDOG flag is used by the client to communicate ongoing status of a long-running task. Update records are sent at the client’s discretion. The frequency of the update depends upon the intended application: A watchdog to provide progress indication will require higher frequency than a daily keep-alive. When the WATCHDOG flag is set along with the START flag, it indicates that the update record provides additional or updated arguments from the original START record. If the START flag is not set, then this indicates only that task is still running, and no new information is provided (servers MUST ignore any arguments). The STOP flag MUST NOT be set in conjunction with the WATCHDOG flag.

The Server MUST respond with TAC_PLUS_ACCT_STATUS_ERROR if the client requests an INVALID option.

## 7. Attribute-Value Pairs

TACACS+ is intended to be an extensible protocol. The attributes used in Authorization and Accounting are not limited by this document. Some attributes are defined below for common use cases, clients MUST use these attributes when supporting the corresponding use cases.

## 7.1. Value Encoding

All attribute values are encoded as printable US-ASCII strings. The following type representations SHOULD be followed

Numeric

All numeric values in an attribute-value string are provided as decimal printable US-ASCII numbers, unless otherwise stated.

Boolean

All boolean attributes are encoded as printable US-ASCII with values "true" or "false".

IP-Address

It is recommended that hosts be specified as a IP address so as to avoid any ambiguities. IPV4 address are specified as US-ASCII octet numerics separated by dots (’.’), IPV6 address text representation defined in RFC 4291.

Date Time

Absolute date/times are specified in seconds since the epoch, 12:00am Jan 1 1970. The timezone MUST be UTC unless a timezone attribute is specified. Stardate is canonically inconsistent and so SHOULD NOT be used.

String

Many values have no specific type representation and so are interpreted as plain strings.

Empty Values

Attributes may be submitted with no value, in which case they consist of the name and the mandatory or optional separator. For example, the attribute "cmd" which has no value is transmitted as a string of four characters "cmd="

## 7.2. Authorization Attributes

service (String)

The primary service. Specifying a service attribute indicates that this is a request for authorization or accounting of that service.

For example: "shell", "tty-server", "connection", "system" and "firewall". This attribute MUST always be included.

protocol (String)

the protocol field may be used to indicate a subset of a service.

cmd (String)

a shell (exec) command. This indicates the command name of the command that is to be run. The "cmd" attribute MUST be specified if service equals "shell".

Authorization of shell commands is a common use-case for the TACACS+ protocol. Command Authorization generally takes one of two forms: session-based and command-based.

For session-based shell authorization, the "cmd" argument will have an empty value. The client determines which commands are allowed in a session according to the arguments present in the authorization.

In command-based authorization, the client requests that the server determine whether a command is allowed by making an authorization request for each command. The "cmd" argument will have the command name as its value.

cmd-arg (String)

an argument to a shell (exec) command. This indicates an argument for the shell command that is to be run. Multiple cmd-arg attributes may be specified, and they are order dependent.

acl (Numeric)

printable US-ASCII number representing a connection access list. Applicable only to session-based shell authorization.

inacl (String)

printable US-ASCII identifier for an interface input access list.

outacl (String)

printable US-ASCII identifier for an interface output access list.

addr (IP-Address)

a network address

addr-pool (String)

The identifier of an address pool from which the client can assign an address.

routing (Boolean)

Specifies whether routing information is to be propagated to, and accepted from this interface.

route (String)

Indicates a route that is to be applied to this interface. Values MUST be of the form "<dst_address> <mask> [<routing_addr>]". If a <routing_addr> is not specified, the resulting route is via the requesting peer.

timeout (Numeric)

an absolute timer for the connection (in minutes). A value of zero indicates no timeout.

idletime (Numeric)

an idle-timeout for the connection (in minutes). A value of zero indicates no timeout.

autocmd (String)

an auto-command to run. Applicable only to session-based shell authorization.

noescape (Boolean)

Prevents user from using an escape character. Applicable only to session-based shell authorization.

nohangup (Boolean)

Boolean. Do not disconnect after an automatic command. Applicable only to session-based shell authorization.

priv-lvl (Numeric)

privilege level to be assigned. Please refer to the Privilege Level section (Section 8) below.

remote_user (String)

remote userid (authen_method must have the value TAC_PLUS_AUTHEN_METH_RCMD). In the case of rcmd authorizations, the authen_method will be set to TAC_PLUS_AUTHEN_METH_RCMD and the remote_user and remote_host attributes will provide the remote user and host information to enable rhost style authorization. The response may request that a privilege level be set for the user.

remote_host (String)

remote host (authen_method must have the value TAC_PLUS_AUTHEN_METH_RCMD)

### 7.3. Accounting Attributes

The following attributes are defined for TACACS+ accounting only. They MUST precede any attribute-value pairs that are defined in the authorization section (Section 5) above.

task_id (String)

Start and stop records for the same event MUST have matching task_id attribute values. The client MUST ensure that active task_ids are not duplicated: a client MUST NOT reuse a task_id a start record until it has sent a stop record for that task_id. Servers MUST not make assumptions about the format of a task_id.

start_time (Date Time)

The time the action started (in seconds since the epoch.).

stop_time (Date Time)

The time the action stopped (in seconds since the epoch.)

elapsed_time (Numeric)

The elapsed time in seconds for the action.

timezone (String)

The timezone abbreviation for all timestamps included in this packet.

event (String)

Used only when "service=system". Current values are "net_acct", "cmd_acct", "conn_acct", "shell_acct" "sys_acct" and "clock_change". These indicate system-level changes. The flags field SHOULD indicate whether the service started or stopped.

reason (String)

Accompanies an event attribute. It describes why the event occurred.

bytes (Numeric)

The number of bytes transferred by this action

bytes_in (Numeric)

The number of bytes transferred by this action from the endstation to the client port

bytes_out (Numeric)

The number of bytes transferred by this action from the client to the endstation port

paks (Numeric)

The number of packets transferred by this action.

paks_in (Numeric)

The number of input packets transferred by this action from the endstation to the client port.

paks_out (Numeric)

The number of output packets transferred by this action from the client port to the endstation.

err_msg (String)

A printable US-ASCII string describing the status of the action.

## 8. Privilege Levels

The TACACS+ Protocol supports flexible authorization schemes through the extensible attributes.

One scheme is built into the protocol and has been extensively used for Session-based shell authorization: Privilege Levels. Privilege Levels are ordered values from 0 to 15 with each level being a superset of the next lower value. Configuration and implementation of the client will map actions (such as the permission to execute of specific commands) to different privilege levels. Pre-defined values are:

```
TAC_PLUS_PRIV_LVL_MAX := 0x0f

TAC_PLUS_PRIV_LVL_ROOT := 0x0f

TAC_PLUS_PRIV_LVL_USER := 0x01

TAC_PLUS_PRIV_LVL_MIN := 0x00
```

A Privilege level can be assigned to a shell (EXEC) session when it starts (for example, TAC_PLUS_PRIV_LVL_USER). The client will permit the actions associated with this level to be executed. This privilege level is returned by the Server in a session-based shell authorization (when "service" equals "shell" and "cmd" is empty). When a user required to perform actions that are mapped to a higher privilege level, then an ENABLE type reauthentication can be initiated by the client. The client will insert the required privilege level into the authentication header for enable authentication request.

The use of Privilege levels to determine session-based access to commands and resources is not mandatory for clients. Although the privilege level scheme is widely supported, its lack of flexibility in requiring a single monotonic hierarchy of permissions means that other session-based command authorization schemes have evolved, and so it is no longer mandatory for clients to use it. However, it is still common enough that it SHOULD be supported by servers.

## 9. TACACS+ Security Considerations

The original TACACS+ Draft[1] from 1998 did not address all of the key security concerns which are considered when designing modern standards. This section addresses known limitations and concerns which will impact overall security of the protocol and systems where this protocol is deployed to manage central authentication, authorization or accounting for network device administration.

Multiple implementations of the protocol described in the draft[1] have been deployed. As the protocol was never standardized, current implementations may be incompatible in non-obvious ways, giving rise to additional security risks. This section does not claim to enumerate all possible security vulnerabilities.

### 9.1. General Security of the Protocol

TACACS+ protocol does not include a security mechanism that would meet modern-day requirements. Support for MD5-based crypto pad encryption fails to provide any kind of transport integrity, which presents at least the following risks:

Accounting information may be modified by the man-in-the-middle attacker, making such logs unsuitable and untrustable for auditing purposes.

Only the body of the request is obfuscated which leaves all header fields open to trivial modification by the man-in-the-middle attacker. For this reason, deployments SHOULD NOT use connections with TAC_PLUS_UNENCRYPTED_FLAG, as mentioned in the recommendations section.

Invalid or misleading values may be inserted by the man-in-the-middle attacker in various fields at known offsets to try and circumvent the authentication or authorization checks even inside the obfuscated body.

While the protocol provides some measure of transport privacy, it is vulnerable to at least the following attacks:

Brute force attacks exploiting increased efficiency of MD5 digest computation.

Known plaintext attacks which may decrease the cost of brute force attack.

Chosen plaintext attacks which may decrease the cost of a brute force attack.

No forward secrecy.

Even though, to the best knowledge of authors, this method of encryption wasn’t rigorously tested, enough information is available that it is best referred to as "obfuscation" and not "encryption".

For these reasons, users deploying TACACS+ protocol in their environments MUST limit access to known clients and MUST control the security of the entire transmission path. Attackers who can guess the key or otherwise break the obfuscation will gain unrestricted and undetected access to all TACACS+ traffic. Ensuring that a centralized AAA system like TACACS+ is deployed on a secured transport is essential to managing the security risk of such an attack.

The following parts of this section enumerate only the session-specific risks which are in addition to general risk associated with bare obfuscation and lack of integrity checking.

## 9.2. Security of Authentication Sessions

Authentication sessions SHOULD be used via a secure transport as the man-in-the-middle attack may completely subvert them. Even CHAP, which may be considered resistant to password interception, is unsafe as it does not protect the username from a trivial man-in-the-middle attack.

This document deprecates the redirection mechanism using the TAC_PLUS_AUTHEN_STATUS_FOLLOW option which was included in the original draft. As part of this process, the secret key for a new server was sent to the client. This public exchange of secret keys means that once one session is broken, it may be possible to leverage that key to attacking connections to other servers. This mechanism SHOULD NOT be used in modern deployments. It MUST NOT be used outside a secured deployment.

## 9.3. Security of Authorization Sessions

Authorization sessions SHOULD be used via a secure transport as it’s trivial to execute a successful man-in-the-middle attacks that changes well-known plaintext in either requests or responses.

As an example, take the field "authen_method". It’s not unusual in actual deployments to authorize all commands received via the device local serial port (a console port) as that one is usually considered secure by virtue of the device located in a physically secure location. If an administrator would configure the authorization system to allow all commands entered by the user on a local console to aid in troubleshooting, that would give all access to all commands to any attacker that would be able to change the "authen_method" from TAC_PLUS_AUTHEN_METH_TACACSPLUS to TAC_PLUS_AUTHEN_METH_LINE. In this regard, the obfuscation provided by the protocol itself wouldn’t help much, because:

Lack of integrity means that any byte in the payload may be changed without either side detecting the change.

Known plaintext means that an attacker would know with certainty which octet is the target of the attack (in this case, 1st octet after the header).

In combination with known plaintext, the attacker can determine with certainty the value of the crypto-pad octet used to obfuscate the original octet.

### 9.4. Security of Accounting Sessions

Accounting sessions are not directly involved in authentication or authorizing operations on the device. However, man-in-the-middle attacker may do any of the following:

Replace accounting data with new valid or garbage which prevents to provide distraction or hide information related to their authentication and/or authorization attack attempts.

Try and poison accounting log with entries designed to make systems behave in unintended ways (which includes TACACS+ server and any other systems that would manage accounting entries).

In addition to these direct manipulations, different client implementations pass different fidelity of accounting data. Some vendors have been observed in the wild that pass sensitive data like passwords, encryption keys and similar as part of the accounting log. Due to lack of strong encryption with perfect forward secrecy, this data may be revealed in future, leading to a security incident.

### 9.5. TACACS+ Best Practices

With respect to the observations about the security issues described above, a network administrator MUST NOT rely on the obfuscation of the TACACS+ protocol and TACACS+ MUST be deployed over networks which ensure privacy and integrity of the communication. TACACS+ MUST be used within a secure deployment. Failure to do so will impact overall network security.

The following recommendations impose restrictions on how the protocol is applied. These restrictions were not imposed in the original draft. New implementations, and upgrades of current implementations, MUST implement these recommendations.

#### 9.5.1. Shared Secrets

TACACS+ servers and clients MUST treat shared secrets as sensitive data to be managed securely, as would be expected for other sensitive data such as identity credential information. TACACS+ servers MUST not leak sensitive data. For example, TACACS+ servers should not expose shared secrets in logs.

TACACS+ servers MUST allow a dedicated secret key to be defined for each client.

TACACS+ servers SHOULD warn administrators if secret keys are not unique per client.

TACACS+ server administrators SHOULD always define a secret for each client.

TACACS+ servers and clients MUST support shared keys that are at least 32 characters long.

TACACS+ clients SHOULD NOT allow servers to be configured without shared secret key, or shared key that is less than 16 characters long.

TACACS+ server administrators SHOULD configure secret keys of minimum 16 characters length.

TACACS+ server administrators SHOULD change secret keys at regular intervals.

### 9.5.2. Connections and Obfuscation

TACACS+ servers MUST allow the definition of individual clients. The servers MUST only accept network connection attempts from these defined, known clients.

TACACS+ servers MUST reject connections with TAC_PLUS_UNENCRYPTED_FLAG set, when there is a shared secret set on the server for the client requesting the connection.

If an invalid shared secret is detected when processing packets for a client, TACACS+ servers MUST NOT accept any new sessions on that connection. TACACS+ servers MUST terminate the connection on completion of any sessions that were previously established with a valid shared secret on that connection.

TACACS+ clients MUST NOT set TAC_PLUS_UNENCRYPTED_FLAG when a secret is defined. Clients MUST be implemented in a way that requires explicit configuration to enable the use of TAC_PLUS_UNENCRYPTED_FLAG.

When a TACACS+ client receives responses from servers where:

- the response packet was received from the server configured with shared key, but the packet jas TAC_PLUS_UNENCRYPTED_FLAG set.

- the response packet was received from the server configured not to use obfuscation, but the packet has TAC_PLUS_UNENCRYPTED_FLAG not set.

then the TACACS+ client MUST close TCP session, and process the response in the same way that a TAC_PLUS_AUTHEN_STATUS_FAIL

(authentication sessions) or TAC_PLUS_AUTHOR_STATUS_FAIL (authorization sessions) was received.

### 9.5.3. Authentication

To allow TACACS+ administraots to select the stronger authentication options, TACACS+ servers MUST allow the administrator to configure the server to only accept challenge/response options for authentication (TAC_PLUS_AUTHEN_TYPE_CHAP or TAC_PLUS_AUTHEN_TYPE_MSCHAP or TAC_PLUS_AUTHEN_TYPE_MSCHAPV2 for authen_type).

TACACS+ server administrators SHOULD enable the option mentioned in the previous paragraph. TACACS+ Server deployments SHOULD ONLY enable other options (such as TAC_PLUS_AUTHEN_TYPE_ASCII or TAC_PLUS_AUTHEN_TYPE_PAP) when unavoidable due to requirements of identity/password systems.

TACACS+ server administrators SHOULD NOT allow the same credentials to be applied in challenge-based (TAC_PLUS_AUTHEN_TYPE_CHAP or TAC_PLUS_AUTHEN_TYPE_MSCHAP or TAC_PLUS_AUTHEN_TYPE_MSCHAPV2) and non challenge-based authen_type options as the insecurity of the latter will compromise the security of the former.

TAC_PLUS_AUTHEN_SENDAUTH and TAC_PLUS_AUTHEN_SENDPASS options mentioned in the original draft SHOULD not be used, due to their security implications. TACACS+ servers SHOULD NOT implement them. If they must be implemented, the servers MUST default to the options being disabled and MUST warn the administrator that these options are not secure.

### 9.5.4. Authorization

The authorization and accounting features are intended to provide extensibility and flexibility. There is a base dictionary defined in this document, but it may be extended in deployments by using new attribute names. The cost of the flexibility is that administrators and implementors MUST ensure that the attribute and value pairs shared between the clients and servers have consistent interpretation.

TACACS+ clients that receive an unrecognised mandatory attribute MUST evaluate server response as if they received TAC_PLUS_AUTHOR_STATUS_FAIL.

### 9.5.5. Redirection Mechanism

The original draft described a redirection mechanism (TAC_PLUS_AUTHEN_STATUS_FOLLOW). This feature is difficult to secure. The option to send secret keys in the server list is particularly insecure, as it can reveal client shared secrets.

TACACS+ servers SHOULD deprecate the redirection mechanism.

If the redirection mechanism is implemented then TACACS+ servers MUST disable it by default, and MUST warn TACACS+ server administrators that it must only be enabled within a secure deployment due to the risks of revealing shared secrets.

TACACS+ clients SHOULD deprecate this feature by treating TAC_PLUS_AUTHEN_STATUS_FOLLOW as TAC_PLUS_AUTHEN_STATUS_FAIL.

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