

Operations  
Internet-Draft  
Intended status: Informational  
Expires: August 22, 2017

T. Dahm  
A. Ota  
Google Inc  
D. Medway Gash  
Cisco Systems, Inc.  
D. Carrel  
vIPtela, Inc.  
L. Grant  
February 18, 2017

The TACACS+ Protocol  
draft-ietf-opsawg-tacacs-06

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.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on August 22, 2017.

Copyright Notice

Copyright (c) 2017 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect

to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

This document may contain material from IETF Documents or IETF Contributions published or made publicly available before November 10, 2008. The person(s) controlling the copyright in some of this material may not have granted the IETF Trust the right to allow modifications of such material outside the IETF Standards Process. Without obtaining an adequate license from the person(s) controlling the copyright in such materials, this document may not be modified outside the IETF Standards Process, and derivative works of it may not be created outside the IETF Standards Process, except to format it for publication as an RFC or to translate it into languages other than English.

## Table of Contents

1.	Introduction . . . . .	3
2.	Technical Definitions . . . . .	4
3.	TACACS+ Connections and Sessions . . . . .	4
3.1.	Connection . . . . .	4
3.2.	Session . . . . .	4
3.3.	Single Connect Mode . . . . .	5
3.4.	Session Completion . . . . .	5
3.5.	Treatment of Enumerated Protocol Values . . . . .	6
3.6.	Text Encoding . . . . .	7
3.7.	Data Obfuscation . . . . .	7
3.8.	The TACACS+ Packet Header . . . . .	9
3.9.	The TACACS+ Packet Body . . . . .	11
4.	Authentication . . . . .	11
4.1.	The Authentication START Packet Body . . . . .	11
4.2.	The Authentication REPLY Packet Body . . . . .	14
4.3.	The Authentication CONTINUE Packet Body . . . . .	15
4.4.	Description of Authentication Process . . . . .	16
4.4.1.	Version Behaviour . . . . .	17
4.4.2.	Common Authentication Flows . . . . .	17
4.4.3.	Aborting an Authentication Session . . . . .	21
5.	Authorization . . . . .	22
5.1.	The Authorization REQUEST Packet Body . . . . .	23
5.2.	The Authorization REPLY Packet Body . . . . .	26
6.	Accounting . . . . .	27
6.1.	The Account REQUEST Packet Body . . . . .	28
6.2.	The Accounting REPLY Packet Body . . . . .	29
7.	Attribute-Value Pairs . . . . .	30
7.1.	Authorization Attributes . . . . .	31
7.2.	Accounting Attributes . . . . .	34

8. Privilege Levels . . . . .	35
9. TACACS+ Security Considerations . . . . .	36
9.1. Security of The Protocol . . . . .	36
9.2. Security of Authentication Sessions . . . . .	37
9.3. Security of Authorization Sessions . . . . .	37
9.4. Security of Accounting Sessions . . . . .	38
9.5. TACACS+ Deployment Recommendations . . . . .	38
9.6. TACACS+ Client Implementation Recommendations . . . . .	39
9.7. TACACS+ Server Implementation Recommendations . . . . .	39
9.8. TACACS+ Security and Operational Concerns . . . . .	40
10. References . . . . .	40
Authors' Addresses . . . . .	41

## 1. Introduction

Terminal Access Controller Access-Control System Plus (TACACS+) was originally conceived 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 have been removed, however the required enumerations are kept.

The TACACS+ protocol separates the functions of Authentication, Authorization and Accounting. It allows for arbitrary length and content authentication exchanges, which will support any authentication mechanism to be utilized with TACACS+ clients. 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 is a fundamental component of the design of TACACS+. The distinction

between them is very important so this document will address each one separately. It is important to note that TACACS+ provides for all three, but an implementation or configuration is not required to employ all three. Each one serves a unique purpose that alone is useful, and together can be quite powerful.

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. A client may also support protocol based access services.

### 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 Connect 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 Connect 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 Connect Mode. This protocol does not define a procedure for changing Single Connect Mode after the first two packets.

If single Connect 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 fit the specific deployment to allocate a long lasting TCP connection to a specific client. 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 Conenction 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 try 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 Connect 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.

### 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 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. The encoding **SHOULD** be UTF-8, and other encodings outside US-ASCII **SHOULD** be deprecated.

### 3.7. Data Obfuscation

The body of packets may be obfuscated. The following sections describe the obfuscation mechanism that is supported in the protocol. In 'The Draft' this process was actually referred to as Encryption, but by modern day standards the mechanisms would not meet the requirements of an encryption mechanism.

The obfuscation mechanism relies on a secret key, it is referring to 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. It is an implementation detail of the server and client, as to whether they will maintain only one key, or a different key for each client or server with which they communicate. For security reasons, the latter options **MUST** be available, but 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 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 is the one byte concatenation of the major and minor version numbers.

The session id is used in network byte order.

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. The handling of the TCP connection by the server is implementation independent.

```
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 do not skip de-obfuscation simply because an incoming packet indicates that it is not obfuscated. If the flag is not set when expected, then it must be dropped.

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 signalled. The underlying TCP connection MAY



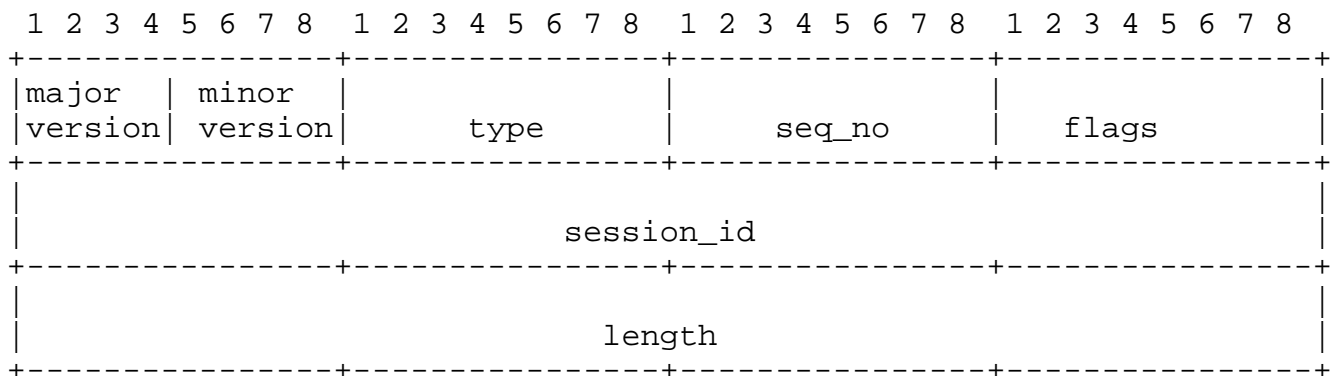
also be closed, if it is not being used for other sessions in single-connect mode.

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

If an error must be declared 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.

### 3.8. 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) . section.

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

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.
- 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 utilizes a name and a fixed password. However, fixed passwords have limitations, mainly in the area of security. Many modern authentication mechanisms utilize "one-time" passwords or a challenge-response query. TACACS+ is designed to support all of these, and be powerful 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

1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
action								priv_lvl								authen_type								authen_service							
user_len								port_len								rem_addr_len								data_len							
user ...																															
port ...																															
rem_addr ...																															
data...																															

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 identifies 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. 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 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 "Asyncl0" to denote the tenth async interface). The `port_len` indicates the length of the port field, in bytes.

`rem_addr, rem_addr_len`

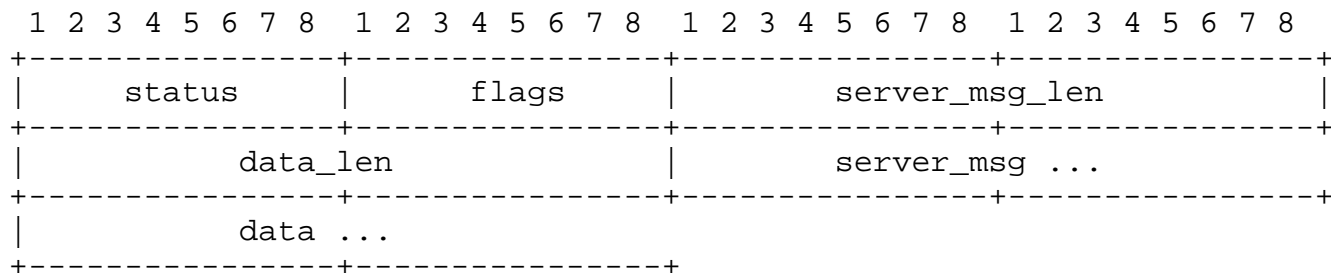
An US-ASCII string indicating the remote location from which the user has connected to the client. It is intended to hold a network address if the user is connected via a network, a caller ID if the user is connected via ISDN or a POTS, or any other remote location information that is available. This 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. If it exists, it is intended to be presented to the user. 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.

```

 1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8
+-----+-----+-----+-----+
|           user_msg len           |           data_len           |
+-----+-----+-----+-----+
|   flags   | user_msg ...   |
+-----+-----+-----+-----+
|   data ...   |
+-----+

```

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 standard set of the kinds of authentication 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, RESTART or FOLLOW. The actions and meanings when the server sends a RESTART, ERROR or FOLLOW 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 from 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.

SENDAUTH is only used for PPP when performing outbound authentication.

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.

Inbound 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. 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.

#### Inbound 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.

#### Inbound 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 PAP hash as defined in the PPP Authentication RFC RFC 1334 [RFC1334] and then

compare that value with the response. The REPLY from the server MUST be a PASS, FAIL or ERROR.

The client conducts the exchange with the endstation and then sends the resulting materials (challenge and response) to the server. So although the selection of the challenge and its length are not an aspect of the TACACS+ protocol, it is strongly recommended that the client/endstation interaction is configured with a secure challenge in mind, and the TACACS+ server can help by rejecting authentications where the challenge is below a minimum length (for example, 8 bytes).

Inbound 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]

Inbound 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]

#### 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 Inbound ASCII login.

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.

#### 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, please 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 legacy and its implementation is optional.

If this feature is not implemented, then the client should treat `TAC_PLUS_AUTHEN_STATUS_FOLLOW` as `TAC_PLUS_AUTHEN_STATUS_FAIL`

When the status equals `TAC_PLUS_AUTHEN_STATUS_FOLLOW` the packet indicates that the TACACS+ server requests that authentication is performed with an alternate server. The data field **MUST** contain ASCII text describing one or more servers. A server description appears like this:

```
[@<protocol>@]<host>>[@<key>]
```

If more than one host is specified, they **MUST** be separated into rows by an ASCII Carriage Return (0x0D).

The protocol and key are optional, and apply only to host in the same row. The protocol can describe an alternate way of performing the authentication, other than TACACS+. If the protocol is not present, then TACACS+ is assumed.

Protocols are ASCII numbers corresponding to the methods listed in the `authen_method` field of authorization packets (defined below). The host is specified as either a fully qualified domain name, or an ASCII numeric IPV4 address specified as octets separated by dots ('.'), or IPV6 address text representation defined in RFC 4291.

If a key is supplied, the client **MAY** use the key in order to authenticate to that host. The client may use a preconfigured key for the host if it has one.

Use of the hosts in a `TAC_PLUS_AUTHEN_STATUS_FOLLOW` packet is at the discretion of the TACACS+ client. It may choose to use any one, all

or none of these hosts. If it chooses to use none, then it MUST treat the authentication as if the return status was 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 in to 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 7.1)

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 clients actions.

### 5.1. The Authorization REQUEST Packet Body

1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
authen_method								priv_lvl								authen_type								authen_service							
user_len								port_len								rem_addr_len								arg_cnt							
arg_1_len								arg_2_len								...								arg_N_len							
user ...																															
port ...																															
rem_addr ...																															
arg_1 ...																															
arg_2 ...																															
...																															
arg_N ...																															

authen\_method

This indicates the authentication method used by the client to acquire the user information.

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 corresponds 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 matches 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 field (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 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.

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 7.1) section below.

## 5.2. The Authorization REPLY Packet Body

```

 1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8
+-----+-----+-----+-----+
|   status           |   arg_cnt           |   server_msg len       |
+-----+-----+-----+-----+
|                   |                   |   arg_1_len           |   arg_2_len           |
+-----+-----+-----+-----+
|   ...             |   arg_N_len          |   server_msg ...      |
+-----+-----+-----+-----+
|   data ...        |
+-----+-----+-----+-----+
|   arg_1 ...       |
+-----+-----+-----+-----+
|   arg_2 ...       |
+-----+-----+-----+-----+
|   ...             |
+-----+-----+-----+-----+
|   arg_N ...       |
+-----+-----+-----+-----+

```

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 an 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 an 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 7.1) 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

```

 1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8
+-----+-----+-----+-----+
|      flags      |  authen_method  |   priv_lvl   |  authen_type  |
+-----+-----+-----+-----+
| authen_service  |   user_len     |   port_len   | rem_addr_len  |
+-----+-----+-----+-----+
|   arg_cnt      |  arg_1_len    |  arg_2_len   |      ...     |
+-----+-----+-----+-----+
|  arg_N_len    |   user ...    |              |              |
+-----+-----+-----+-----+
|  port ...    |              |              |              |
+-----+-----+-----+-----+
| rem_addr ... |              |              |              |
+-----+-----+-----+-----+
|  arg_1 ...   |              |              |              |
+-----+-----+-----+-----+
|  arg_2 ...   |              |              |              |
+-----+-----+-----+-----+
|  ...        |              |              |              |
+-----+-----+-----+-----+
|  arg_N ...   |              |              |              |
+-----+-----+-----+-----+

```

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.

```

 1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8  1 2 3 4 5 6 7 8
+-----+-----+-----+-----+
|          server_msg len          |          data_len          |
+-----+-----+-----+-----+
|      status      |          server_msg ...          |
+-----+-----+-----+-----+
|          data ...          |
+-----+-----+

```

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 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 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. Update records are sent at the client's discretion if the task has not finished.

#### 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. When the WATCHDOG flag is set along with the START flag, it indicates that the update record is a duplicate of the original START record. If the START flag is not set, then this indicates only that task is still running. 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.

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

All boolean attributes are encoded with values "true" or "false".

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

Absolute times are specified in seconds since the epoch, 12:00am Jan 1 1970. The timezone MUST be UTC unless a timezone attribute is specified.

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="

## 7.1. Authorization Attributes

service

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

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

cmd

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`

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`

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

`inacl`

US-ASCII identifier for an interface input access list.

`outacl`

US-ASCII identifier for an interface output access list.

`addr`

a network address

`addr-pool`

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`

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`

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

`idletime`



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

autocmd

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

priv-lvl

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

remote\_user

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

remote host (authen\_method must have the value TAC\_PLUS\_AUTHEN\_METH\_RCMD)

callback-dialstring

Indicates that callback is to be done. Value is a dialstring, or empty. Empty value indicates that the service MAY choose to get the dialstring through other means.

callback-line

The line number to use for a callback.

callback-rotary

The rotary number to use for a callback.

nocallback-verify

Do not require authentication after callback.

## 7.2. 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

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

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

stop\_time

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

elapsed\_time

The elapsed time in seconds for the action.

timezone

The timezone abbreviation for all timestamps included in this packet.

event

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

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

bytes

The number of bytes transferred by this action

bytes\_in

The number of input bytes transferred by this action to the port

bytes\_out

The number of output bytes transferred by this action from the port

paks

The number of packets transferred by this action.

paks\_in

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

paks\_out

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

status

The numeric status value associated with the action. This is a signed four (4) byte word in network byte order. 0 is defined as success. Negative numbers indicate errors. Positive numbers indicate non-error failures. The exact status values may be defined by the client.

err\_msg

An 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 in to 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 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, in a way similar to su in unix. 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

Although in widespread use, the TACACS+ protocol (as defined in "the Draft") does not meet modern security standards on its own. For this reason, the authors intend to follow up this document with a more secure version of the protocol.

TACACS+ was originally specified in "The Draft" (1998) is incomplete, and leaves key points unspecified. As a result, software authors have had to make implementation choices about what should, or should not, be done in certain situations. These implementation choices are somewhat constrained by ad hoc interoperability tests. That is, all TACACS+ clients and servers interoperate, so there is a rough consensus on how the protocol works.

### 9.1. Security of The Protocol

The major security issue with the TACACS+ protocol is the absence of a security mechanism that would meet modern day requirements. The draft included an "encryption" mechanism, however this has been more correctly referred to as "obfuscation" in this document.

The choice of obfuscating the body but not the packet header means that an attacker can modify the header without detection.

For example, a "session\_id" can be replaced by an alternate one, which could allow an unprivileged administrator to "steal" the authorization from a session for a privileged administrator. An attacker could also update the "flags" field to indicate that one or the other end of a connection requires TAC\_PLUS\_UNENCRYPTED\_FLAG, which would subvert the obfuscation mechanism.

Without application of alternative secure transport, implementations rely on limiting access to known clients. Attacks who can guess the key or break the obfuscation method can gain unrestricted and undetected access to all TACACS+ traffic. The negative side effects of such a successful attack cannot be overstated.

## 9.2. Security of Authentication Sessions

The authentication options include options which MUST NOT be used outside a secured deployment. Specifically, options which permit the exchange of clear-text passwords or MSCHAPv1 and MS-CHAPv2. As of the publication of this document, there has been no similar attacks on the CHAP protocol.

Section 4.4.3 permits the redirection of a session to another server via the TAC\_PLUS\_AUTHEN\_STATUS\_FOLLOW mechanism. As part of this process, the secret key for a new server can be sent to the client. This public exchange of secret keys means that once one session is broken, it may be possible to leverage that attack to attacking connections to other servers. This option MUST NOT be used outside a secured deployment.

## 9.3. Security of Authorization Sessions

TACACS+ authorization is specifically separate from authentication. Careful consideration must be given to whether this mode is appropriate for the target deployment. Authorization sessions are not cryptographically linked to any authentication sessions. Instead, sessions are tied together implicitly by the contents of the other fields, such as "use", "port", "rem\_addr", etc.

The specification allows for the exchange of attribute-value pairs. While a few such attributes are defined here, the protocol is extensible, and vendors can define their own attributes. There is no registry for such attributes, and in the absence of a published specification, no way for a client or server to know the meaning of a new attribute.

As a result, implementors MUST ensure that new attribute-value pairs are used consistently to communicate between client and server implementations.

#### 9.4. Security of Accounting Sessions

The security considerations for accounting sessions are largely the same as for authorization sessions. This section describes additional issues specific to accounting sessions.

There is no way in TACACS+ to signal that accounting is required. There is no way for a server to signal a client how often accounting is required. The accounting packets are received solely at the clients discretion. Adding such functionality would assist with auditing of user actions.

The "task\_id" field is defined only for accounting packets, and not for authentication or authorization packets. As such, it is difficult to correlate accounting data with a previous authentication or authorization request.

#### 9.5. TACACS+ Deployment Recommendations

Due to the above concerns with the protocol, it is critical that it be deployed in a secure manner. The following recommendations are made for those deploying and configuring TACACS+ as a solution for Device Administration:

Secure the Deployment: TACACS+ does not provide modern security so TACACS+ MUST BE employed over networks which ensure privacy and integrity of the communication. The way this is ensured will depend upon the organisational means: a dedicated and secure management network where available in enterprise deployments, or IPsec where dedicated networks are not available.

Always set a secret key (recommended minimum 14 characters) on the client and server when configuring the connection between them.

Servers MUST be configured with a list of known clients. Servers MUST be configured to reject requests from clients not on the list. A unique secret key SHOULD be configured for every individual client.

Restrict to TAC\_PLUS\_AUTHEN\_TYPE\_CHAP for authen\_type where possible. Use other options only when unavoidable due to requirements of identity/password systems.

Servers SHOULD be restricted to requiring TACACS+ authentication for authorization requests (i.e. TAC\_PLUS\_AUTHEN\_METH\_TACACSPLUS is used).

Avoid the use of the redirection mechanism. TAC\_PLUS\_AUTHEN\_STATUS\_FOLLOW, specifically avoid the option to send secret keys in the server list.

Take care when applying extensions to the dictionary of authorization/accounting arguments. Ensure that the client and server use of new argument names are consistent.

#### 9.6. TACACS+ Client Implementation Recommendations

When implementing TACACS+ Clients it is recommended:

Clients SHOULD not use TAC\_PLUS\_UNENCRYPTED\_FLAG, even on networks that are considered secure.

Ignore redirects to hosts which are outside of the pre-configured range or list. A client SHOULD ignore any key provided via TAC\_PLUS\_AUTHEN\_STATUS\_FOLLOW, and SHOULD instead use a preconfigured key for that host.

If receiving an unknown mandatory authorization attribute, behave as if it had received TAC\_PLUS\_AUTHOR\_STATUS\_FAIL. For full details, refer to (Authorization attributes section).

#### 9.7. TACACS+ Server Implementation Recommendations

When implementing TACACS+ Servers, it is recommended:

Server SHOULD reject all connections which have the TAC\_PLUS\_UNENCRYPTED\_FLAG with applicable ERROR response for type of packet.

Servers MUST permit configuration of secret keys per individual client. Servers SHOULD warn administrators if secret keys are not unique per client.

On detection of an invalid shared secret: Servers SHOULD NOT accept any new sessions on a connection, and terminate the connection on completion of any sessions previously established with a valid shared secret.

Allow the administrator to mandate : - TAC\_PLUS\_AUTHEN\_TYPE\_CHAP for authen\_type - TAC\_PLUS\_AUTHEN\_METH\_TACACSPLUS for authen\_method in authorization - Minimum length for shared secrets

## 9.8. TACACS+ Security and Operational Concerns

This section identifies some of the known security and operational concerns. It is important to acknowledge that TACACS+ on its own does not provide modern levels of security, and that it MUST be used within a secure deployment.

The "encryption" is based upon MD5. In modern terms this can be regarded merely as "obfuscation".

Only the packet body (not header) is obfuscated. For example, session\_id, flags containing TAC\_PLUS\_UNENCRYPTED\_FLAG is exposed in cleartext.

Support of insecure authentication protocols such as plaintext, MS-CHAP.

Difficulty to correlate authentication, authorization, and accounting requests for a single unit of end client activity.

Potential confusion between clients and servers from different vendors of the meaning of specific argument attributes.

Potential confusion between clients and servers from different vendors of the meaning of specific commands.

In summary: It is strongly advised that TACACS+ MUST be used within a secure deployment. Failure to do so may impact overall network security.

## 10. References

[TheDraft]

Carrel, D. and L. Grant, "The TACACS+ Protocol Version 1.78", June 1997, <<https://tools.ietf.org/html/draft-grant-tacacs-02>>.

[RFC1321] Rivest, R., "The MD5 Message-Digest Algorithm", RFC 1321, April 1992.

[RFC1334] Lloyd, B. and W. Simpson, "PPP Authentication Protocols", RFC 1334, DOI 10.17487/RFC1334, October 1992, <<http://www.rfc-editor.org/info/rfc1334>>.

[RFC1750] Eastlake 3rd, D., Crocker, S., and J. Schiller, "Randomness Recommendations for Security", RFC 1750, DOI 10.17487/RFC1750, December 1994, <<http://www.rfc-editor.org/info/rfc1750>>.



[RFC2433] Zorn, G. and S. Cobb, "Microsoft PPP CHAP Extensions", RFC 2433, DOI 10.17487/RFC2433, October 1998, <<http://www.rfc-editor.org/info/rfc2433>>.

[RFC2759] Zorn, G., "Microsoft PPP CHAP Extensions, Version 2", RFC 2759, DOI 10.17487/RFC2759, January 2000, <<http://www.rfc-editor.org/info/rfc2759>>.

#### Authors' Addresses

Thorsten Dahm  
Google Inc  
1600 Amphitheatre Parkway  
Mountain View, CA 94043  
US

EMail: [thorstendlux@google.com](mailto:thorstendlux@google.com)

Andrej Ota  
Google Inc  
1600 Amphitheatre Parkway  
Mountain View, CA 94043  
US

EMail: [aota@google.com](mailto:aota@google.com)

Douglas C. Medway Gash  
Cisco Systems, Inc.  
170 West Tasman Dr.  
San Jose, CA 95134  
US

Phone: +44 0208 8244508  
EMail: [dcmgash@cisco.com](mailto:dcmgash@cisco.com)

David Carrel  
vIPtela, Inc.  
1732 North First St.  
San Jose, CA 95112  
US

EMail: [dcarrel@viptela.com](mailto:dcarrel@viptela.com)

Lol Grant