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RADIUS Extension for Digest Authentication

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Abstract

This document defines an extension to the Remote Authentication Dial-In User Service (RADIUS) protocol to enable support of Digest Authentication, for use with HTTP-style protocols like the Session Initiation Protocol (SIP) and HTTP.

Table of Contents

1. Introduction

1.1. Motivation

The HTTP Digest Authentication mechanism, defined in [RFC2617], was subsequently adapted for use with SIP [RFC3261]. Due to the limitations and weaknesses of Digest Authentication (see [RFC2617], Section 4), additional authentication and encryption mechanisms are defined in SIP [RFC3261], including Transport Layer Security (TLS) [RFC4346] and Secure MIME (S/MIME) [RFC3851]. However, Digest Authentication support is mandatory in SIP implementations, and Digest Authentication is the preferred way for a SIP UA to authenticate itself to a proxy server. Digest Authentication is used in other protocols as well.

To simplify the provisioning of users, there is a need to support this authentication mechanism within Authentication, Authorization, and Accounting (AAA) protocols such as RADIUS [RFC2865] and Diameter [RFC3588].

This document defines an extension to the RADIUS protocol to enable support of Digest Authentication for use with SIP, HTTP, and other HTTP-style protocols using this authentication method. Support for Digest mechanisms such as Authentication and Key Agreement (AKA) [RFC3310] is also supported. A companion document [RFC4740] defines support for Digest Authentication within Diameter.

1.2. Terminology

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

The use of normative requirement key words in this document shall apply only to RADIUS client and RADIUS server implementations that include the features described in this document. This document creates no normative requirements for existing implementations.

HTTP-style protocol
: The term "HTTP-style" denotes any protocol that uses HTTP-like headers and uses HTTP Digest Authentication as described in [RFC2617]. Examples are HTTP and the Session Initiation Protocol (SIP).

NAS (Network Access Server)
: The RADIUS client.

nonce
An unpredictable value used to prevent replay attacks. The nonce generator may use cryptographic mechanisms to produce nonces it can recognize without maintaining state.

protection space
HTTP-style protocols differ in their definition of the protection space. For HTTP, it is defined as the combination of the realm and canonical root URL of the requested resource for which the use is authorized by the RADIUS server. In the case of SIP, the realm string alone defines the protection space.

SIP UA (SIP User Agent)
An Internet endpoint that uses the Session Initiation Protocol.

SIP UAS (SIP User Agent Server)
A logical entity that generates a response to a SIP (Session Initiation Protocol) request.

1.3. Overview

HTTP Digest is a challenge-response protocol used to authenticate a client's request to access some resource on a server. Figure 1 shows a single HTTP Digest transaction.

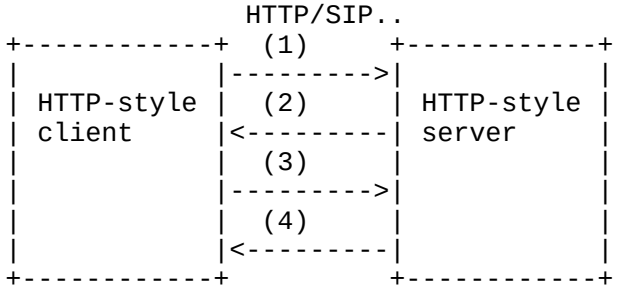


Figure 1: Digest Operation without RADIUS

If the client sends a request without any credentials (1), the server will reply with an error response (2) containing a nonce. The client creates a cryptographic digest from parts of the request, from the nonce it received from the server, and from a shared secret. The client retransmits the request (3) to the server, but now includes the digest within the packet. The server does the same digest calculation as the client and compares the result with the digest it received in (3). If the digest values are identical, the server grants access to the resource and sends a positive response to the

client (4). If the digest values differ, the server sends a negative response to the client (4).

Instead of maintaining a local user database, the server could use RADIUS to access a centralized user database. However, RADIUS [RFC2865] does not include support for HTTP Digest Authentication. The RADIUS client cannot use the User-Password Attribute, since it does not receive a password from the HTTP-style client. The CHAP-Challenge and CHAP-Password attributes described in [RFC1994] are also not suitable since the Challenge Handshake Authentication Protocol (CHAP) algorithm is not compatible with HTTP Digest.

This document defines new attributes that enable the RADIUS server to perform the digest calculation defined in [RFC2617], providing support for Digest Authentication as a native authentication mechanism within RADIUS.

The nonces required by the digest algorithm are generated by the RADIUS server. Generating them in the RADIUS client would save a round-trip, but introduce security and operational issues. Some digest algorithms -- e.g., AKA [RFC3310] -- would not work.

Figure 2 depicts a scenario in which the HTTP-style server defers authentication to a RADIUS server. Entities A and B communicate using HTTP or SIP, while entities B and C communicate using RADIUS.

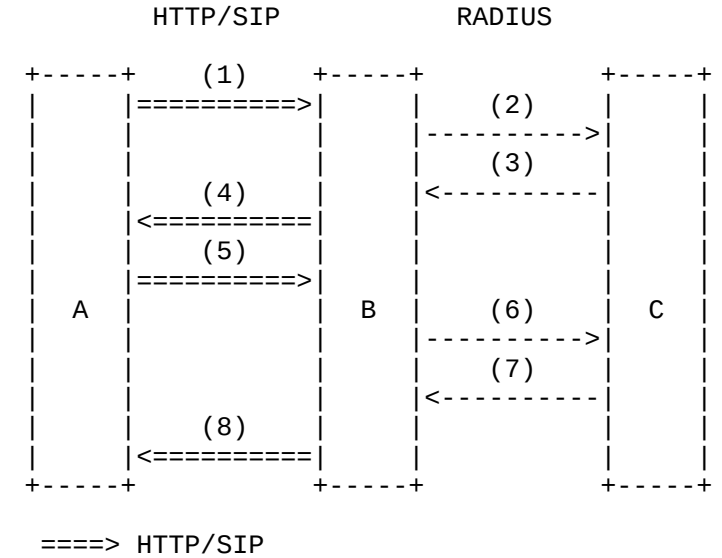


Figure 2: HTTP Digest over RADIUS

The entities have the following roles:

A: HTTP client / SIP UA

B: {HTTP server / HTTP proxy server / SIP proxy server / SIP UAS} acting also as a RADIUS NAS

C: RADIUS server

The following messages are sent in this scenario:

A sends B an HTTP/SIP request without an Authorization header (step 1). B sends an Access-Request packet with the newly defined Digest-Method and Digest-URI attributes but without a Digest-Nonce Attribute to the RADIUS server, C (step 2). C chooses a nonce and responds with an Access-Challenge (step 3). This Access-Challenge contains Digest attributes, from which B takes values to construct an HTTP/SIP "(Proxy) Authorization required" response. B sends this response to A (step 4). A resends its request with its credentials (step 5). B sends an Access-Request to C (step 6). C checks the credentials and replies with Access-Accept or Access-Reject (step 7). Depending on C's result, B processes A's request or rejects it with a "(Proxy) Authorization required" response (step 8).

2. Detailed Description

2.1. RADIUS Client Behavior

The attributes described in this document are sent in cleartext. Therefore, were a RADIUS client to accept secure connections (HTTPS or SIPS) from HTTP-style clients, this could result in information intentionally protected by HTTP-style clients being sent in the clear during RADIUS exchange.

2.1.1. Credential Selection

On reception of an HTTP-style request message, the RADIUS client checks whether it is authorized to authenticate the request. Where an HTTP-style request traverses several proxies, and each of the proxies requests to authenticate the HTTP-style client, the request at the HTTP-style server may contain multiple credential sets.

The RADIUS client can use the realm directive in HTTP to determine which credentials are applicable. Where none of the realms are of interest, the RADIUS client MUST behave as though no relevant credentials were sent. In all situations, the RADIUS client MUST send zero or exactly one credential to the RADIUS server. The RADIUS

client MUST choose the credential of the (Proxy-)Authorization header if the realm directive matches its locally configured realm.

2.1.2. Constructing an Access-Request

If a matching (Proxy-)Authorization header is present and contains HTTP Digest information, the RADIUS client checks the nonce parameter.

If the RADIUS client recognizes the nonce, it takes the header directives and puts them into a RADIUS Access-Request packet. It puts the response directive into a Digest-Response Attribute and the realm, nonce, digest-uri, qop, algorithm, cnonce, nc, username, and opaque directives into the respective Digest-Realm, Digest-Nonce, Digest-URI, Digest-Qop, Digest-Algorithm, Digest-CNonce, Digest-Nonce-Count, Digest-Username, and Digest-Opaque attributes. The RADIUS client puts the request method into the Digest-Method Attribute.

Due to HTTP syntactic requirements, quoted strings found in HTTP Digest directives may contain escaped quote and backslash characters. When translating these directives into RADIUS attributes, the RADIUS client only removes the leading and trailing quote characters which surround the directive value, it does not unescape anything within the string. See Section 3 for an example.

If the Quality of Protection (qop) directive's value is 'auth-int', the RADIUS client calculates H(entity-body) as described in [RFC2617], Section 3.2.1, and puts the result in a Digest-Entity-Body-Hash Attribute.

The RADIUS client adds a Message-Authenticator Attribute, defined in [RFC3579], and sends the Access-Request packet to the RADIUS server.

The RADIUS server processes the packet and responds with an Access-Accept or an Access-Reject.

2.1.3. Constructing an Authentication-Info Header

After having received an Access-Accept from the RADIUS server, the RADIUS client constructs an Authentication-Info header:

- If the Access-Accept packet contains a Digest-Response-Auth Attribute, the RADIUS client checks the Digest-Qop Attribute:
  - If the Digest-Qop Attribute's value is 'auth' or not specified, the RADIUS client puts the Digest-Response-Auth Attribute's

content into the Authentication-Info header's rspauth directive of the HTTP-style response.

* If the Digest-Qop Attribute's value is 'auth-int', the RADIUS client ignores the Access-Accept packet and behaves as if it had received an Access-Reject packet (Digest-Response-Auth can't be correct as the RADIUS server does not know the contents of the HTTP-style response's body).

o If the Access-Accept packet contains a Digest-HA1 Attribute, the RADIUS client checks the qop and algorithm directives in the Authorization header of the HTTP-style request it wants to authorize:

* If the qop directive is missing or its value is 'auth', the RADIUS client ignores the Digest-HA1 Attribute. It does not include an Authentication-Info header in its HTTP-style response.

* If the qop directive's value is 'auth-int' and at least one of the following conditions is true, the RADIUS client calculates the contents of the HTTP-style response's rspauth directive:

+ The algorithm directive's value is 'MD5-sess' or 'AKAv1-MD5-sess'.

+ IP Security (IPsec) is configured to protect traffic between the RADIUS client and RADIUS server with IPsec (see Section 8).

The RADIUS client creates the HTTP-style response message and calculates the hash of this message's body. It uses the result and the Digest-URI Attribute's value of the corresponding Access-Request packet to perform the H(A2) calculation. It takes the Digest-Nonce, Digest-Nonce-Count, Digest-CNonce, and Digest-Qop values of the corresponding Access-Request and the Digest-HA1 Attribute's value to finish the computation of the rspauth value.

o If the Access-Accept packet contains neither a Digest-Response-Auth nor a Digest-HA1 Attribute, the RADIUS client will not create an Authentication-Info header for its HTTP-style response.

When the RADIUS server provides a Digest-Nextnonce Attribute in the Access-Accept packet, the RADIUS client puts the contents of this attribute into a nextnonce directive. Now it can send an HTTP-style response.

2.1.4. Failed Authentication

If the RADIUS client did receive an HTTP-style request without a (Proxy-)Authorization header matching its locally configured realm value, it obtains a new nonce and sends an error response (401 or 407) containing a (Proxy-)Authenticate header.

If the RADIUS client receives an Access-Challenge packet in response to an Access-Request containing a Digest-Nonce Attribute, the RADIUS server did not accept the nonce. If a Digest-Stale Attribute is present in the Access-Challenge and has a value of 'true' (without surrounding quotes), the RADIUS client sends an error response (401 or 407) containing a WWW-/Proxy-Authenticate header with the stale directive set to 'true' and the digest directives derived from the Digest-* attributes.

If the RADIUS client receives an Access-Reject from the RADIUS server, it sends an error response to the HTTP-style request it has received. If the RADIUS client does not receive a response, it retransmits or fails over to another RADIUS server as described in [RFC2865].

2.1.5. Obtaining Nonces

The RADIUS client has two ways to obtain nonces: it has received one in a Digest-Nextnonce Attribute of a previously received Access-Accept packet, or it asks the RADIUS server for one. To do the latter, it sends an Access-Request containing a Digest-Method and a Digest-URI Attribute, but without a Digest-Nonce Attribute. It adds a Message-Authenticator (see [RFC3579]) Attribute to the Access-Request packet. The RADIUS server chooses a nonce and responds with an Access-Challenge containing a Digest-Nonce Attribute.

The RADIUS client constructs a (Proxy-)Authenticate header using the received Digest-Nonce and Digest-Realm attributes to fill the nonce and realm directives. The RADIUS server can send Digest-Qop, Digest-Algorithm, Digest-Domain, and Digest-Opaque attributes in the Access-Challenge carrying the nonce. If these attributes are present, the client MUST use them.

2.2. RADIUS Server Behavior

If the RADIUS server receives an Access-Request packet with a Digest-Method and a Digest-URI Attribute but without a Digest-Nonce Attribute, it chooses a nonce. It puts the nonce into a Digest-Nonce Attribute and sends it in an Access-Challenge packet to the RADIUS client. The RADIUS server MUST add Digest-Realm, Message-Authenticator (see [RFC3579]), SHOULD add Digest-Algorithm and one or

more Digest-Qop, and MAY add Digest-Domain or Digest-Opaque attributes to the Access-Challenge packet.

2.2.1. General Attribute Checks

If the RADIUS server receives an Access-Request packet containing a Digest-Response Attribute, it looks for the following attributes:

Digest-Realm, Digest-Nonce, Digest-Method, Digest-URI, Digest-Qop, Digest-Algorithm, and Digest-Username. Depending on the content of Digest-Algorithm and Digest-Qop, it looks for Digest-Entity-Body-Hash, Digest-CNonce, and Digest-AKA-Auts, too. See [RFC2617] and [RFC3310] for details. If the Digest-Algorithm Attribute is missing, 'MD5' is assumed. If the RADIUS server has issued a Digest-Opaque Attribute along with the nonce, the Access-Request MUST have a matching Digest-Opaque Attribute.

If mandatory attributes are missing, it MUST respond with an Access-Reject packet.

The RADIUS server removes '\' characters that escape quote and '\' characters from the text values it has received in the Digest-* attributes.

If the mandatory attributes are present, the RADIUS server MUST check if the RADIUS client is authorized to serve users of the realm mentioned in the Digest-Realm Attribute. If the RADIUS client is not authorized, the RADIUS server MUST send an Access-Reject. The RADIUS server SHOULD log the event so as to notify the operator, and MAY take additional action such as sending an Access-Reject in response to all future requests from this client, until this behavior is reset by management action.

The RADIUS server determines the age of the nonce in the Digest-Nonce by using an embedded timestamp or by looking it up in a local table. The RADIUS server MUST check the integrity of the nonce if it embeds the timestamp in the nonce. Section 2.2.2 describes how the server handles old nonces.

2.2.2. Authentication

If the Access-Request message passes the checks described above, the RADIUS server calculates the digest response as described in [RFC2617]. To look up the password, the RADIUS server uses the RADIUS User-Name Attribute. The RADIUS server MUST check if the user identified by the User-Name Attribute:

- is authorized to access the protection space and

- o is authorized to use the URI included in the SIP-AOR Attribute, if this attribute is present.

If any of those checks fails, the RADIUS server MUST send an Access-Reject.

Correlation between User-Name and SIP-AOR AVP values is required just to avoid any user from registering or misusing a SIP-AOR that has been allocated to a different user.

All values required for the digest calculation are taken from the Digest attributes described in this document. If the calculated digest response equals the value received in the Digest-Response Attribute, the authentication was successful.

If the response values match, but the RADIUS server considers the nonce in the Digest-Nonce Attribute too old, it sends an Access-Challenge packet containing a new nonce and a Digest-Stale Attribute with a value of 'true' (without surrounding quotes).

If the response values don't match, the RADIUS server responds with an Access-Reject.

2.2.3. Constructing the Reply

If the authentication was successful, the RADIUS server adds an attribute to the Access-Accept packet that can be used by the RADIUS client to construct an Authentication-Info header:

- o If the Digest-Qop Attribute's value is 'auth' or unspecified, the RADIUS server SHOULD put a Digest-Response-Auth Attribute into the Access-Accept packet.

- o If the Digest-Qop Attribute's value is 'auth-int' and at least one of the following conditions is true, the RADIUS server SHOULD put a Digest-HA1 Attribute into the Access-Accept packet:

  - * The Digest-Algorithm Attribute's value is 'MD5-sess' or 'AKAv1-MD5-sess'.

  - * IPsec is configured to protect traffic between the RADIUS client and RADIUS server with IPsec (see Section 8).

In all other cases, Digest-Response-Auth or Digest-HA1 MUST NOT be sent.

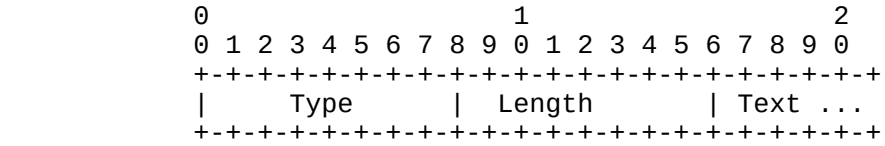
RADIUS servers MAY construct a Digest-Nextnonce Attribute and add it to the Access-Accept packet. This is useful to limit the lifetime of

a nonce and to save a round-trip in future requests (see nextnonce discussion in [RFC2617], Section 3.2.3). The RADIUS server adds a Message-Authenticator Attribute (see [RFC3579]) and sends the Access-Accept packet to the RADIUS client.

If the RADIUS server does not accept the nonce received in an Access-Request packet but authentication was successful, the RADIUS server MUST send an Access-Challenge packet containing a Digest-Stale Attribute set to 'true' (without surrounding quotes). The RADIUS server MUST add Message-Authenticator (see [RFC3579]), Digest-Nonce, Digest-Realm, SHOULD add Digest-Algorithm and one or more Digest-Qops, and MAY add Digest-Domain or Digest-Opaque attributes to the Access-Challenge packet.

3. New RADIUS Attributes

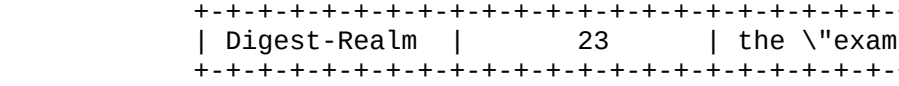
If not stated otherwise, the attributes have the following format:



Quote and backslash characters in Digest-* attributes representing HTTP-style directives with a quoted-string syntax are escaped. The surrounding quotes are removed. They are syntactical delimiters that are redundant in RADIUS. For example, the directive

realm="the \"example\" value"

is represented as follows:



3.1. Digest-Response Attribute

Description

If this attribute is present in an Access-Request message, a RADIUS server implementing this specification MUST treat the Access-Request as a request for Digest Authentication. When a RADIUS client receives a (Proxy-)Authorization header, it puts the request-digest value into a Digest-Response Attribute. This attribute (which enables the user to prove possession of the password) MUST only be used in Access-Request packets.

Type
: 103 for Digest-Response.

Length
: >= 3

Text
: When using HTTP Digest, the text field is 32 octets long and contains a hexadecimal representation of a 16-octet digest value as it was calculated by the authenticated client. Other digest algorithms MAY define different digest lengths. The text field MUST be copied from request-digest of digest-response [RFC2617] without surrounding quotes.

3.2. Digest-Realm Attribute

Description
: This attribute describes a protection space component of the RADIUS server. HTTP-style protocols differ in their definition of the protection space. See [RFC2617], Section 1.2, for details. It MUST only be used in Access-Request, Access-Challenge, and Accounting-Request packets.

Type
: 104 for Digest-Realm

Length
: >= 3

Text
: In Access-Requests, the RADIUS client takes the value of the realm directive (realm-value according to [RFC2617]) without surrounding quotes from the HTTP-style request it wants to authenticate. In Access-Challenge packets, the RADIUS server puts the expected realm value into this attribute.

3.3. Digest-Nonce Attribute

Description
: This attribute holds a nonce to be used in the HTTP Digest calculation. If the Access-Request had a Digest-Method and a Digest-URI but no Digest-Nonce Attribute, the RADIUS server MUST put a Digest-Nonce Attribute into its Access-Challenge packet. This attribute MUST only be used in Access-Request and Access-Challenge packets.

Type
: 105 for Digest-Nonce

Length
: >= 3

Text
: In Access-Requests, the RADIUS client takes the value of the nonce directive (nonce-value in [RFC2617]) without surrounding quotes from the HTTP-style request it wants to authenticate. In Access-Challenge packets, the attribute contains the nonce selected by the RADIUS server.

3.4. Digest-Response-Auth Attribute

Description
: This attribute enables the RADIUS server to prove possession of the password. If the previously received Digest-Qop Attribute was 'auth-int' (without surrounding quotes), the RADIUS server MUST send a Digest-HA1 Attribute instead of a Digest-Response-Auth Attribute. The Digest-Response-Auth Attribute MUST only be used in Access-Accept packets. The RADIUS client puts the attribute value without surrounding quotes into the rspauth directive of the Authentication-Info header.

Type
: 106 for Digest-Response-Auth.

Length
: >= 3

Text
: The RADIUS server calculates a digest according to Section 3.2.3 of [RFC2617] and copies the result into this attribute. Digest algorithms other than the one defined in [RFC2617] MAY define digest lengths other than 32.

3.5. Digest-Nextnonce Attribute

This attribute holds a nonce to be used in the HTTP Digest calculation.

Description
: The RADIUS server MAY put a Digest-Nextnonce Attribute into an Access-Accept packet. If this attribute is present, the RADIUS client MUST put the contents of this attribute into the nextnonce directive of an Authentication-Info header in its HTTP-style response. This attribute MUST only be used in Access-Accept packets.

Type
: 107 for Digest-Nextnonce

Length
: >= 3

Text
: It is recommended that this text be base64 or hexadecimal data.

3.6. Digest-Method Attribute

Description
: This attribute holds the method value to be used in the HTTP Digest calculation. This attribute MUST only be used in Access-Request and Accounting-Request packets.

Type
: 108 for Digest-Method

Length
: >= 3

Text
: In Access-Requests, the RADIUS client takes the value of the request method from the HTTP-style request it wants to authenticate.

3.7. Digest-URI Attribute

Description
: This attribute is used to transport the contents of the digest-uri directive or the URI of the HTTP-style request. It MUST only be used in Access-Request and Accounting-Request packets.

Type
: 109 for Digest-URI

Length
: >= 3

Text
: If the HTTP-style request has an Authorization header, the RADIUS client puts the value of the uri directive found in the HTTP-style request Authorization header (known as "digest-uri-value" in Section 3.2.2 of [RFC2617]) without surrounding quotes into this attribute. If there is no Authorization header, the RADIUS client takes the value of the request URI from the HTTP-style request it wants to authenticate.

3.8. Digest-Qop Attribute

Description
: This attribute holds the Quality of Protection parameter that influences the HTTP Digest calculation. This attribute MUST only be used in Access-Request, Access-Challenge, and Accounting-Request packets. A RADIUS client SHOULD insert one of the Digest-Qop attributes it has received in a previous Access-Challenge packet. RADIUS servers SHOULD insert at least one Digest-Qop Attribute in an Access-Challenge packet. Digest-Qop is optional in order to preserve backward compatibility with a minimal implementation of [RFC2069].

Type
110 for Digest-Qop
Length
>= 3
Text
In Access-Requests, the RADIUS client takes the value of the qop directive (qop-value as described in [RFC2617]) from the HTTP-style request it wants to authenticate. In Access-Challenge packets, the RADIUS server puts a desired qop-value into this attribute. If the RADIUS server supports more than one "quality of protection" value, it puts each qop-value into a separate Digest-Qop Attribute.

3.9. Digest-Algorithm Attribute

Description
This attribute holds the algorithm parameter that influences the HTTP Digest calculation. It MUST only be used in Access-Request, Access-Challenge and Accounting-Request packets. If this attribute is missing, MD5 is assumed.
Type
111 for Digest-Algorithm
Length
>= 3
Text
In Access-Requests, the RADIUS client takes the value of the algorithm directive (as described in [RFC2617], Section 3.2.1) from the HTTP-style request it wants to authenticate. In Access-Challenge packets, the RADIUS server SHOULD put the desired algorithm into this attribute.

3.10. Digest-Entity-Body-Hash Attribute

Description
When using the qop-value 'auth-int', a hash of the HTTP-style message body's contents is required for digest calculation. Instead of sending the complete body of the message, only its hash value is sent. This hash value can be used directly in the digest calculation.

The clarifications described in section 22.4 of [RFC3261] about the hash of empty entity bodies apply to the Digest-Entity-Body-Hash Attribute. This attribute MUST only be sent in Access-Request packets.
Type
112 for Digest-Entity-Body-Hash
Length
>= 3

Text
The attribute holds the hexadecimal representation of H(entity-body). This hash is required by certain authentication mechanisms, such as HTTP Digest with quality of protection set to 'auth-int'. RADIUS clients MUST use this attribute to transport the hash of the entity body when HTTP Digest is the authentication mechanism and the RADIUS server requires that the integrity of the entity body (e.g., qop parameter set to 'auth-int') be verified. Extensions to this document may define support for authentication mechanisms other than HTTP Digest.

3.11. Digest-CNonce Attribute

Description
This attribute holds the client nonce parameter that is used in the HTTP Digest calculation. It MUST only be used in Access-Request packets.
Type
113 for Digest-CNonce
Length
>= 3
Text
This attribute includes the value of the cnonce-value [RFC2617] without surrounding quotes, taken from the HTTP-style request.

3.12. Digest-Nonce-Count Attribute

Description
This attribute includes the nonce count parameter that is used to detect replay attacks. The attribute MUST only be used in Access-Request packets.
Type
114 for Digest-Nonce-Count
Length
10
Text
In Access-Requests, the RADIUS client takes the value of the nc directive (nc-value according to [RFC2617]) without surrounding quotes from the HTTP-style request it wants to authenticate.

3.13. Digest-Username Attribute

Description
This attribute holds the user name used in the HTTP Digest calculation. The RADIUS server MUST use this attribute only for the purposes of calculating the digest. In order to determine the appropriate user credentials, the RADIUS server

MUST use the User-Name (1) Attribute, and MUST NOT use the Digest-Username Attribute. This attribute MUST only be used in Access-Request and Accounting-Request packets.

Type
115 for Digest-Username

Length
>= 3

Text
In Access-Requests, the RADIUS client takes the value of the username directive (username-value according to [RFC2617]) without surrounding quotes from the HTTP-style request it wants to authenticate.

3.14. Digest-Opaque Attribute

Description
This attribute holds the opaque parameter that is passed to the HTTP-style client. The HTTP-style client will pass this value back to the server (i.e., the RADIUS client) without modification. This attribute MUST only be used in Access-Request and Access-Challenge packets.

Type
116 for Digest-Opaque

Length
>= 3

Text
In Access-Requests, the RADIUS client takes the value of the opaque directive (opaque-value according to [RFC2617]) without surrounding quotes from the HTTP-style request it wants to authenticate and puts it into this attribute. In Access-Challenge packets, the RADIUS server MAY include this attribute.

3.15. Digest-Auth-Param Attribute

Description
This attribute is a placeholder for future extensions and corresponds to the auth-param parameter defined in Section 3.2.1 of [RFC2617]. The Digest-Auth-Param is the mechanism whereby the RADIUS client and RADIUS server can exchange auth-param extension parameters contained within Digest headers that are not understood by the RADIUS client and for which there are no corresponding stand-alone attributes.

Unlike the previously listed Digest-* attributes, the Digest-Auth-Param contains not only the value but also the parameter name, since the parameter name is unknown to the RADIUS client. If the Digest header contains several unknown parameters, then

the RADIUS implementation MUST repeat this attribute, and each instance MUST contain one different unknown Digest parameter/value combination. This attribute MUST ONLY be used in Access-Request, Access-Challenge, Access-Accept, and Accounting-Request packets.

Type
117 for Digest-Auth-Param

Length
>= 3

Text
The text consists of the whole parameter, including its name, the equal sign ('='), and quotes.

3.16. Digest-AKA-Auts Attribute

Description
This attribute holds the auts parameter that is used in the Digest AKA [RFC3310] calculation. It is only used if the algorithm of the digest-response denotes a version of AKA Digest [RFC3310]. This attribute MUST only be used in Access-Request packets.

Type
118 for Digest-AKA-Auts

Length
>= 3

Text
In Access-Requests, the RADIUS client takes the value of the auts directive (auts-param according to Section 3.4 of [RFC3310]) without surrounding quotes from the HTTP-style request it wants to authenticate.

3.17. Digest-Domain Attribute

Description
When a RADIUS client has asked for a nonce, the RADIUS server MAY send one or more Digest-Domain attributes in its Access-Challenge packet. The RADIUS client puts them into the quoted, space-separated list of URIs of the domain directive of a WWW-Authenticate header. Together with Digest-Realm, the URIs in the list define the protection space (see [RFC2617], Section 3.2.1) for some HTTP-style protocols. This attribute MUST only be used in Access-Challenge and Accounting-Request packets.

Type
119 for Digest-Domain

Length
3

Text
: This attribute consists of a single URI that defines a protection space component.

3.18. Digest-Stale Attribute

Description
: This attribute is sent by a RADIUS server in order to notify the RADIUS client whether it has accepted a nonce. If the nonce presented by the RADIUS client was stale, the value is 'true' and is 'false' otherwise. The RADIUS client puts the content of this attribute into a stale directive of the WWW-Authenticate header in the HTTP-style response to the request it wants to authenticate. The attribute MUST only be used in Access-Challenge packets.

Type
: 120 for Digest-Stale

Length
: 3

Text
: The attribute has either the value 'true' or 'false' (both values without surrounding quotes).

3.19. Digest-HA1 Attribute

Description
: This attribute is used to allow the generation of an Authentication-Info header, even if the HTTP-style response's body is required for the calculation of the rspauth value. It SHOULD be used in Access-Accept packets if the required quality of protection (qop) is 'auth-int'.

  This attribute MUST NOT be sent if the qop parameter was not specified or has a value of 'auth' (in this case, use Digest-Response-Auth instead).

  The Digest-HA1 Attribute MUST only be sent by the RADIUS server or processed by the RADIUS client if at least one of the following conditions is true:

  + The Digest-Algorithm Attribute's value is 'MD5-sess' or 'AKAv1-MD5-sess'.

  + IPsec is configured to protect traffic between the RADIUS client and RADIUS server with IPsec (see Section 8).

  This attribute MUST only be used in Access-Accept packets.

Type
: 121 for Digest-HA1

Length
: >= 3

Text
: This attribute contains the hexadecimal representation of H(A1) as described in [RFC2617], Sections 3.1.3, 3.2.1, and 3.2.2.

3.20. SIP-AOR Attribute

Description
: This attribute is used for the authorization of SIP messages. The SIP-AOR Attribute identifies the URI, the use of which must be authenticated and authorized. The RADIUS server uses this attribute to authorize the processing of the SIP request. The SIP-AOR can be derived from, for example, the To header field in a SIP REGISTER request (user under registration), or the From header field in other SIP requests. However, the exact mapping of this attribute to SIP can change due to new developments in the protocol. This attribute MUST only be used when the RADIUS client wants to authorize SIP users and MUST only be used in Access-Request packets.

Type
: 122 for SIP-AOR

Length
: >= 3

Text
: The syntax of this attribute corresponds either to a SIP URI (with the format defined in [RFC3261] or a tel URI (with the format defined in [RFC3966]).

  The SIP-AOR Attribute holds the complete URI, including parameters and other parts. It is up to the RADIUS server as to which components of the URI are regarded in the authorization decision.

4. Diameter Compatibility

This document defines support for Digest Authentication in RADIUS. A companion document "Diameter Session Initiation Protocol (SIP) Application" [RFC4740] defines support for Digest Authentication in Diameter, and addresses compatibility issues between RADIUS and Diameter.

5. Table of Attributes

The following table provides a guide to which attributes may be found in which kinds of packets, and in what quantity.

Access-Request	Access-Accept	Access-Reject	Access-Challenge	Acct-Req	#	Attribute
0-1	0	0	0	0-1	1	User-Name
0-1	0	0	1	0	24	State [4]
1	1	1	1	0-1	80	Message-Authenticator
0-1	0	0	0	0	103	Digest-Response
0-1	0	0	1	0-1	104	Digest-Realm
0-1	0	0	1	0	105	Digest-Nonce
0	0-1	0	0	0	106	Digest-Response-Auth [1][2]
0	0-1	0	0	0	107	Digest-Nextnonce
1	0	0	0	0-1	108	Digest-Method
0-1	0	0	0	0-1	109	Digest-URI
0-1	0	0	0+	0-1	110	Digest-Qop
0-1	0	0	0-1	0-1	111	Digest-Algorithm [3]
0-1	0	0	0	0	112	Digest-Entity-Body-Hash
0-1	0	0	0	0	113	Digest-CNonce
0-1	0	0	0	0	114	Digest-Nonce-Count
0-1	0	0	0	0-1	115	Digest-Username
0-1	0	0	0-1	0	116	Digest-Opaque
0+	0+	0	0+	0+	117	Digest-Auth-Param
0-1	0	0	0	0	118	Digest-AKA-Auts
0	0	0	0+	0+	119	Digest-Domain
0	0	0	0-1	0	120	Digest-Stale
0	0-1	0	0	0	121	Digest-HA1 [1][2]
0-1	0	0	0	0	122	SIP-AOR

The following table defines the meaning of the above table entries.

0	This attribute MUST NOT be present in the packet.
0+	Zero or more instances of this attribute MAY be present in the packet.
0-1	Zero or one instance of this attribute MAY be present in the packet.

[Note 1] Digest-HA1 MUST be used instead of Digest-Response-Auth if Digest-Qop is 'auth-int'.

[Note 2] Digest-Response-Auth MUST be used instead of Digest-HA1 if Digest-Qop is 'auth'.

[Note 3] If Digest-Algorithm is missing, 'MD5' is assumed.

[Note 4] An Access-Challenge MUST contain a State attribute, which is copied to the subsequent Access-Request. A server receiving an Access-Request that contains a State attribute MUST respond with either an Access-Accept or an Access-Reject; the server MUST NOT respond with an Access-Challenge.

6. Examples

This is an example selected from the traffic between a softphone (A), a Proxy Server (B), and an example.com RADIUS server (C). The communication between the Proxy Server and a SIP Public Switched Telephone Network (PSTN) gateway is omitted for brevity. The SIP messages are not shown completely.

The password of user '12345678' is 'secret'. The shared secret between the RADIUS client and server is 'secret'. To ease testing, only the last byte of the RADIUS authenticator changes between requests. In a real implementation, this would be a serious flaw.

A->B

```
INVITE sip:97226491335@example.com SIP/2.0
From: <sip:12345678@example.com>
To: <sip:97226491335@example.com>
```

B->A

```
SIP/2.0 100 Trying
```

B->C

```
Code = Access-Request (1)
Packet identifier = 0x7c (124)
Length = 97
Authenticator = F5E55840E324AA49D216D9DBD069807C
NAS-IP-Address = 192.0.2.38
NAS-Port = 5
User-Name = 12345678
Digest-Method = INVITE
Digest-URI = sip:97226491335@example.com
Message-Authenticator = 7600D5B0BDC33987A60D5C6167B28B3B
```

C->B

```
Code = Access-challenge (11)
Packet identifier = 0x7c (124)
Length = 72
Authenticator = EBE20199C26EFEAD69BF8AB0E786CA4D
Digest-Nonce = 3bada1a0
Digest-Realm = example.com
Digest-Qop = auth
Digest-Algorithm = MD5
Message-Authenticator = 5DA18ED3BBC9513DCBDE0A37F51B7DE3
```

```
   B->A

      SIP/2.0 407 Proxy Authentication Required
      Proxy-Authenticate: Digest realm="example.com"
           ,nonce="3bada1a0",qop=auth,algorithm=MD5
      Content-Length: 0

   A->B

      ACK sip:97226491335@example.com SIP/2.0

   A->B

      INVITE sip:97226491335@example.com SIP/2.0
      Proxy-Authorization: Digest nonce="3bada1a0"
           ,realm="example.com"
           ,response="756933f735fcd93f90a4bbdd5467f263"
           ,uri="sip:97226491335@example.com",username="12345678"
           ,qop=auth,algorithm=MD5
           ,cnonce="56593a80,nc="00000001"

      From: <sip:12345678@example.com>
      To: <sip:97226491335@example.com>

   B->C

      Code = Access-Request (1)
      Packet identifier = 0x7d (125)
      Length = 221
      Authenticator = F5E55840E324AA49D216D9DBD069807D
      NAS-IP-Address = 192.0.2.38
      NAS-Port = 5
      User-Name = 12345678
      Digest-Method = INVITE
      Digest-URI = sip:97226491335@example.com
      Digest-Realm = example.com
      Digest-Qop = auth
      Digest-Algorithm = MD5
      Digest-CNonce = 56593a80
      Digest-Nonce = 3bada1a0
      Digest-Nonce-Count = 00000001
      Digest-Response = 756933f735fcd93f90a4bbdd5467f263
      Digest-Username = 12345678
      SIP-AOR = sip:12345678@example.com
      Message-Authenticator = B6C7F7F8D11EF261A26933D234561A60
```

```
C->B

   Code = Access-Accept (2)
   Packet identifier = 0x7d (125)
   Length = 72
   Authenticator = FFDD74D6470D21CB6FC4D6056BE245D2
   Digest-Response-Auth = f847de948d12285f8f4199e366f1af21
   Message-Authenticator = 7B76E2F10A7067AF601938BF13B0A62E

B->A

   SIP/2.0 180 Ringing

B->A

   SIP/2.0 200 OK

A->B

   ACK sip:97226491335@example.com SIP/2.0
```

A second example shows the traffic between a web browser (A), a web server (B), and a RADIUS server (C).

```
A->B

   GET /index.html HTTP/1.1

B->C

   Code = Access-Request (1)
   Packet identifier = 0x7e (126)
   Length = 68
   Authenticator = F5E55840E324AA49D216D9DBD069807E
   NAS-IP-Address = 192.0.2.38
   NAS-Port = 5
   Digest-Method = GET
   Digest-URI = /index.html
   Message-Authenticator = 690BFC95E88DF3B185F15CD78E469992
```

```
C->B

   Code = Access-challenge (11)
   Packet identifier = 0x7e (126)
   Length = 72
   Authenticator = 2EE5EB01C02C773B6C6EC8515F565E8E
   Digest-Nonce = a3086ac8
   Digest-Realm = example.com
   Digest-Qop = auth
   Digest-Algorithm = MD5
   Message-Authenticator = 646DB2B0AF9E72FFF2CF7FEB33C4952A

B->A

   HTTP/1.1 401 Authentication Required
   WWW-Authenticate: Digest realm="example.com",
       nonce="a3086ac8",qop=auth,algorithm=MD5
   Content-Length: 0

A->B

   GET /index.html HTTP/1.1
   Authorization: Digest = algorithm=MD5,qop=auth,nonce="a3086ac8"
        ,nc="00000001",cnonce="56593a80"
        ,realm="example.com"
        ,response="a4fac45c27a30f4f244c54a2e99fa117"
        ,uri="/index.html",username="12345678"

B->C

   Code = Access-Request (1)
   Packet identifier = 0x7f (127)
   Length = 176
   Authenticator = F5E55840E324AA49D216D9DBD069807F
   NAS-IP-Address = 192.0.2.38
   NAS-Port = 5
   User-Name = 12345678
   Digest-Method = GET
   Digest-URI = /index.html
   Digest-Realm = example.com
   Digest-Qop = auth
   Digest-Algorithm = MD5
   Digest-CNonce = 56593a80
   Digest-Nonce = a3086ac8
   Digest-Nonce-Count = 00000001
   Digest-Response = a4fac45c27a30f4f244c54a2e99fa117
   Digest-Username = 12345678
   Message-Authenticator = 237D85C1478C70C67EEAF22A9C456821
```

C->B

```
Code = Access-Accept (2)
Packet identifier = 0x7f (127)
Length = 72
Authenticator = 6364FA6ED66012847C05A0895607C694
Digest-Response-Auth = 08c4e942d1d0a191de8b3aa98cd35147
Message-Authenticator = 43795A3166492AD2A890AD57D5F97D56
```

B->A

```
HTTP/1.1 200 OK
...

<html>
...
```

7. IANA Considerations

The following values from the RADIUS Attribute Types number space were assigned in [RFC4590]. This document requests that the values in the table below be entered within the existing registry.

Attribute	#
Digest-Response	103
Digest-Realm	104
Digest-Nonce	105
Digest-Response-Auth	106
Digest-Nextnonce	107
Digest-Method	108
Digest-URI	109
Digest-Qop	110
Digest-Algorithm	111
Digest-Entity-Body-Hash	112
Digest-CNonce	113
Digest-Nonce-Count	114
Digest-Username	115
Digest-Opaque	116
Digest-Auth-Param	117
Digest-AKA-Auts	118
Digest-Domain	119
Digest-Stale	120
Digest-HA1	121
SIP-AOR	122

8. Security Considerations

The RADIUS extensions described in this document enable RADIUS to transport the data that is required to perform a digest calculation. As a result, RADIUS inherits the vulnerabilities of HTTP Digest (see [RFC2617], Section 4) in addition to RADIUS security vulnerabilities described in [RFC2865], Section 8, and [RFC3579], Section 4.

An attacker compromising a RADIUS client or proxy can carry out man-in-the-middle attacks even if the paths between A, B and B, C (Figure 2) have been secured with TLS or IPsec.

The RADIUS server MUST check the Digest-Realm Attribute it has received from a client. If the RADIUS client is not authorized to serve HTTP-style clients of that realm, it might be compromised.

8.1. Denial of Service

RADIUS clients implementing the extension described in this document may authenticate HTTP-style requests received over the Internet. As compared with the use of RADIUS to authenticate link-layer network access, attackers may find it easier to cover their tracks in such a scenario.

An attacker can attempt a denial-of-service attack on one or more RADIUS servers by sending a large number of HTTP-style requests. To make simple denial-of-service attacks more difficult, the RADIUS server MUST check whether it has generated the nonce received from an HTTP-style client. This SHOULD be done statelessly. For example, a nonce could consist of a cryptographically random part and some kind of signature provided by the RADIUS client, as described in [RFC2617], Section 3.2.1.

8.2. Confidentiality and Data Integrity

The attributes described in this document are sent in cleartext. RADIUS servers SHOULD include Digest-Qop and Digest-Algorithm attributes in Access-Challenge messages. A man in the middle can modify or remove those attributes in a bidding down attack, causing the RADIUS client to use a weaker authentication scheme than intended.

The Message-Authenticator Attribute, described in [RFC3579], Section 3.2 MUST be included in Access-Request, Access-Challenge, Access-Reject, and Access-Accept messages that contain attributes described in this specification.

The Digest-HA1 Attribute contains no random components if the algorithm is 'MD5' or 'AKAv1-MD5'. This makes offline dictionary attacks easier and enables replay attacks.

Some parameter combinations require the protection of RADIUS packets against eavesdropping and tampering. Implementations SHOULD try to determine automatically whether IPsec is configured to protect traffic between the RADIUS client and the RADIUS server. If this is not possible, the implementation checks a configuration parameter telling it whether IPsec will protect RADIUS traffic. The default value of this configuration parameter tells the implementation that RADIUS packets will not be protected.

HTTP-style clients can use TLS with server-side certificates together with HTTP-Digest Authentication. Instead of TLS, IPsec can be used, too. TLS or IPsec secure the connection while Digest Authentication authenticates the user. The RADIUS transaction can be regarded as one leg on the path between the HTTP-style client and the HTTP-style server. To prevent RADIUS from representing the weak link, a RADIUS client receiving an HTTP-style request via TLS or IPsec could use an equally secure connection to the RADIUS server. There are several ways to achieve this, for example:

- The RADIUS client may reject HTTP-style requests received over TLS or IPsec.
- The RADIUS client may require that traffic be sent and received over IPsec.

RADIUS over IPsec, if used, MUST conform to the requirements described in [RFC3579], Section 4.2.

9. References

9.1. Normative References

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Appendix A - Changes from RFC 4590

This Appendix lists the major changes between [RFC4590] and this document. Minor changes, including style, grammar, spelling, and editorial changes are not mentioned here.

- The Table of Attributes (Section 5) now indicates that the Digest-Method Attribute is required within an Access-Request. Also, an entry has been added for the State attribute. The table also includes entries for Accounting-Request messages. As noted in the examples, the User-Name Attribute is not necessary when requesting a nonce.

- Two errors in attribute assignment have been corrected within the IANA Considerations (Section 7). Digest-Response-Auth is assigned attribute 106, and Digest-Nextnonce is assigned attribute 107.

- Several errors in the examples section have been corrected.

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