

Internet Engineering Task Force  
Internet-Draft  
Updates: [4462](#) (if approved)  
Intended status: Standards Track  
Expires: May 10, 2019

S. Sorce  
H. Kario  
Red Hat, Inc.  
Nov 6, 2018

**GSS-API Key Exchange with SHA2**  
**draft-ietf-curdle-gss-keyex-sha2-07**

Abstract

This document specifies additions and amendments to [RFC4462](#). It defines a new key exchange method that uses SHA-2 for integrity and deprecates weak DH groups. The purpose of this specification is to modernize the cryptographic primitives used by GSS Key Exchanges.

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 <https://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 May 10, 2019.

Copyright Notice

Copyright (c) 2018 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 (<https://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.

## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">2</a>
<a href="#">2.</a>	Rationale . . . . .	<a href="#">2</a>
<a href="#">3.</a>	Document Conventions . . . . .	<a href="#">2</a>
<a href="#">4.</a>	New Diffie-Hellman Key Exchange methods . . . . .	<a href="#">3</a>
<a href="#">5.</a>	New Elliptic Curve Diffie-Hellman Key Exchange methods . . . .	<a href="#">4</a>
<a href="#">5.1.</a>	Generic GSS-API Key Exchange with ECDH . . . . .	<a href="#">4</a>
<a href="#">5.2.</a>	ECDH Key Exchange Methods . . . . .	<a href="#">8</a>
<a href="#">6.</a>	IANA Considerations . . . . .	<a href="#">9</a>
<a href="#">7.</a>	Security Considerations . . . . .	<a href="#">9</a>
<a href="#">7.1.</a>	New Finite Field DH mechanisms . . . . .	<a href="#">9</a>
<a href="#">7.2.</a>	New Elliptic Curve DH mechanisms . . . . .	<a href="#">10</a>
<a href="#">7.3.</a>	GSSAPI Delegation . . . . .	<a href="#">10</a>
<a href="#">8.</a>	References . . . . .	<a href="#">10</a>
<a href="#">8.1.</a>	Normative References . . . . .	<a href="#">10</a>
<a href="#">8.2.</a>	Informative References . . . . .	<a href="#">11</a>
	Authors' Addresses . . . . .	<a href="#">12</a>

## [1.](#) Introduction

SSH GSS-API Methods [[RFC4462](#)] allows the use of GSSAPI for authentication and key exchange in SSH. It defines three exchange methods all based on DH groups and SHA-1. This document updates [RFC4462](#) with new methods intended to support environments that desire to use the SHA-2 cryptographic hash functions.

## [2.](#) Rationale

Due to security concerns with SHA-1 [[RFC6194](#)] and with MODP groups with less than 2048 bits [[NIST-SP-800-131Ar1](#)] we propose the use of the SHA-2 [[RFC6234](#)] based hashes with DH group14, group15, group16, group17 and group18 [[RFC3526](#)]. Additionally we add support for key exchange based on Elliptic Curve Diffie Hellman with the NIST P-256, P-384 and P-521 as well as the X25519 and X448 curves. Following the rationale of [[RFC8268](#)] only SHA-256 and SHA-512 hashes are used for DH groups. For NIST curves the same curve-to-hashing algorithm pairing used in [[RFC5656](#)] is adopted for consistency.

## [3.](#) Document Conventions

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



#### 4. New Diffie-Hellman Key Exchange methods

This document adopts the same naming convention defined in [\[RFC4462\]](#) to define families of methods that cover any GSS-API mechanism used with a specific Diffie-Hellman group and SHA-2 Hash combination.

The following new key exchange algorithms are defined:

Key Exchange Method Name	Implementation Recommendations
gss-group14-sha256-*	SHOULD/RECOMMENDED
gss-group15-sha512-*	MAY/OPTIONAL
gss-group16-sha512-*	SHOULD/RECOMMENDED
gss-group17-sha512-*	MAY/OPTIONAL
gss-group18-sha512-*	MAY/OPTIONAL

Each key exchange method is implicitly registered by this document. The IESG is considered to be the owner of all these key exchange methods; this does NOT imply that the IESG is considered to be the owner of the underlying GSS-API mechanism.

Each method in any family of methods specifies GSS-API-authenticated Diffie-Hellman key exchanges as described in [Section 2.1 of \[RFC4462\]](#). The method name for each method is the concatenation of the family method name with the Base64 encoding of the MD5 hash [\[RFC1321\]](#) of the ASN.1 DER encoding [\[ISO-IEC-8825-1\]](#) of the underlying GSS-API mechanism's OID. Base64 encoding is described in [Section 6.8 of \[RFC2045\]](#).

#### Family method references

Family Name prefix	Hash Function	Group	Reference
gss-group14-sha256-	SHA-256	2048-bit MODP	<a href="#">Section 3 of [RFC3526]</a>
gss-group15-sha512-	SHA-512	3072-bit MODP	<a href="#">Section 4 of [RFC3526]</a>
gss-group16-sha512-	SHA-512	4096-bit MODP	<a href="#">Section 5 of [RFC3526]</a>
gss-group17-sha512-	SHA-512	6144-bit MODP	<a href="#">Section 6 of [RFC3526]</a>
gss-group18-sha512-	SHA-512	8192-bit MODP	<a href="#">Section 7 of [RFC3526]</a>



## 5. New Elliptic Curve Diffie-Hellman Key Exchange methods

In [\[RFC5656\]](#) new SSH key exchange algorithms based on Elliptic Curve Cryptography are introduced. We reuse much of [section 4](#) to define GSS-API-authenticated ECDH Key Exchanges.

Additionally we utilize also the curves defined in [\[I-D.ietf-curdle-ssh-curves\]](#) to complement the 3 classic NIST defined curves required by [\[RFC5656\]](#).

### 5.1. Generic GSS-API Key Exchange with ECDH

This section reuses much of the scheme defined in [Section 2.1 of \[RFC4462\]](#) and combines it with the scheme defined in [Section 4 of \[RFC5656\]](#); in particular, all checks and verification steps prescribed in [Section 4 of \[RFC5656\]](#) apply here as well.

For curve25519 and curve448 related computations see [Section 6 of \[RFC7748\]](#); implementations MUST check whether the computed Diffie-Hellman shared secret is the all-zero value and abort if so.

This section defers to [\[RFC7546\]](#) as the source of information on GSS-API context establishment operations, [Section 3](#) being the most relevant. All Security Considerations described in [\[RFC7546\]](#) apply here too.

The parties generate each an ephemeral key pair, according to Section 3.2.1 of [\[SEC1v2\]](#). Keys are verified upon receipt by the parties according to Section 3.2.3.1 of [\[SEC1v2\]](#).

For NIST Curves keys use uncompressed point representation and must be converted using the algorithm in Section 2.3.4 of [\[SEC1v2\]](#). If the conversion fails or the point is transmitted using compressed representation, the key exchange MUST fail.

A GSS Context is established according to [Section 4 of \[RFC5656\]](#); The client initiates the establishment using `GSS_Init_sec_context()` and the server completes it using `GSS_Accept_sec_context()`. For the negotiation, the client MUST set `mutual_req_flag` and `integ_req_flag` to "true". In addition, `deleg_req_flag` MAY be set to "true" to request access delegation, if requested by the user. Since the key exchange process authenticates only the host, the setting of `anon_req_flag` is immaterial to this process. If the client does not support the "gssapi-keyex" user authentication method described in [Section 4 of \[RFC4462\]](#), or does not intend to use that method in conjunction with the GSS-API context established during key exchange, then `anon_req_flag` SHOULD be set to "true". Otherwise, this flag MAY be set to true if the client wishes to hide its identity. This key



exchange process will exchange only a single token once the context has been established, therefore the `replay_det_req_flag` and `sequence_req_flag` SHOULD be set to "false".

The client MUST include its public key with the first message it sends to the server during this process; if the server receives more than one key or none at all, the key exchange MUST fail.

During GSS Context establishment multiple tokens may be exchanged by the client and the server. When the GSS Context is established (`major_status` is `GSS_S_COMPLETE`) the parties check that `mutual_state` and `integ_avail` are both "true". If not the key exchange MUST fail.

Once a party receives the peer's public key it proceeds to compute a shared secret K. For NIST Curves the computation is done according to Section 3.3.1 of [\[SEC1v2\]](#) and the resulting value z is converted to the octet string K using the conversion defined in Section 2.3.5 of [\[SEC1v2\]](#). For curve25519 and curve448 the algorithm in [Section 6 of \[RFC7748\]](#) is used instead.

To verify the integrity of the handshake, peers use the Hash Function defined by the selected Key Exchange method to calculate H:

$$H = \text{hash}(V\_C \parallel V\_S \parallel I\_C \parallel I\_S \parallel K\_S \parallel Q\_C \parallel Q\_S \parallel K).$$

The `GSS_GetMIC()` call is used by the server with H as the payload and generates a MIC. The `GSS_VerifyMIC()` call is used by the client to verify the MIC.

If any `GSS_Init_sec_context()` or `GSS_Accept_sec_context()` returns a `major_status` other than `GSS_S_COMPLETE` or `GSS_S_CONTINUE_NEEDED`, or any other GSS-API call returns a `major_status` other than `GSS_S_COMPLETE`, the key exchange MUST fail. The same recommendations expressed in [Section 2.1 of \[RFC4462\]](#) are followed with regards to error reporting.

The following is an overview of the key exchange process:





Client	Server
-----	-----
Generate ephemeral key pair.	
Calls GSS_Init_sec_context().	
SSH_MSG_KEXGSS_INIT ----->	
	Verify received key is valid.
(Optional)	<----- SSH_MSG_KEXGSS_HOSTKEY
(Loop)	
	Calls GSS_Accept_sec_context().
	<----- SSH_MSG_KEXGSS_CONTINUE
Calls GSS_Init_sec_context().	
SSH_MSG_KEXGSS_CONTINUE ----->	
	Calls GSS_Accept_sec_context().
	Generate ephemeral key pair.
	Compute shared secret.
	Computes hash H.
	Calls GSS_GetMIC( H ) = MIC.
	<----- SSH_MSG_KEXGSS_COMPLETE
Verify received key is valid.	
Compute shared secret.	
Compute hash = H	
Calls GSS_VerifyMIC( MIC, H )	

This is implemented with the following messages:

The client sends:

```

byte      SSH_MSG_KEXGSS_INIT
string    output_token (from GSS_Init_sec_context())
string    Q_C, client's ephemeral public key octet string

```

The server may responds with:

```

byte      SSH_MSG_KEXGSS_HOSTKEY
string    server public host key and certificates (K_S)

```

The server sends:

```

byte      SSH_MSG_KEXGSS_CONTINUE
string    output_token (from GSS_Accept_sec_context())

```

Each time the client receives the message described above, it makes another call to GSS\_Init\_sec\_context().



The client sends:

```
byte      SSH_MSG_KEXGSS_CONTINUE
string    output_token (from GSS_Init_sec_context())
```

As the final message the server sends either:

```
byte      SSH_MSG_KEXGSS_COMPLETE
string    Q_S, server's ephemeral public key octet string
string    mic_token (MIC of H)
boolean   TRUE
string    output_token (from GSS_Accept_sec_context())
```

Or the following if no output\_token is available:

```
byte      SSH_MSG_KEXGSS_COMPLETE
string    Q_S, server's ephemeral public key octet string
string    mic_token (MIC of H)
boolean   FALSE
```

The hash H is computed as the HASH hash of the concatenation of the following:

```
string    V_C, the client's version string (CR, NL excluded)
string    V_S, server's version string (CR, NL excluded)
string    I_C, payload of the client's SSH_MSG_KEXINIT
string    I_S, payload of the server's SSH_MSG_KEXINIT
string    K_S, server's public host key
string    Q_C, client's ephemeral public key octet string
string    Q_S, server's ephemeral public key octet string
mpint     K, shared secret
```

This value is called the exchange hash, and it is used to authenticate the key exchange. The exchange hash SHOULD be kept secret. If no SSH\_MSG\_KEXGSS\_HOSTKEY message has been sent by the server or received by the client, then the empty string is used in place of K\_S when computing the exchange hash.

Since this key exchange method does not require the host key to be used for any encryption operations, the SSH\_MSG\_KEXGSS\_HOSTKEY message is OPTIONAL. If the "null" host key algorithm described in [Section 5 of \[RFC4462\]](#) is used, this message MUST NOT be sent.

If the client receives a SSH\_MSG\_KEXGSS\_CONTINUE message after a call to GSS\_Init\_sec\_context() has returned a major\_status code of GSS\_S\_COMPLETE, a protocol error has occurred and the key exchange MUST fail.



If the client receives a SSH\_MSG\_KEXGSS\_COMPLETE message and a call to GSS\_Init\_sec\_context() does not result in a major\_status code of GSS\_S\_COMPLETE, a protocol error has occurred and the key exchange MUST fail.

## 5.2. ECDH Key Exchange Methods

The following new key exchange methods are defined:

Key Exchange Method Name	Implementation Recommendations
gss-nistp256-sha256-*	SHOULD/RECOMMENDED
gss-nistp384-sha384-*	MAY/OPTIONAL
gss-nistp521-sha512-*	MAY/OPTIONAL
gss-curve25519-sha256-*	SHOULD/RECOMMENDED
gss-curve448-sha512-*	MAY/OPTIONAL

Each key exchange method is implicitly registered by this document. The IESG is considered to be the owner of all these key exchange methods; this does NOT imply that the IESG is considered to be the owner of the underlying GSS-API mechanism.

Each method in any family of methods specifies GSS-API-authenticated Elliptic Curve Diffie-Hellman key exchanges as described in [Section 5.1](#). The method name for each method is the concatenation of the family method name with the Base64 encoding of the MD5 hash [RFC1321] of the ASN.1 DER encoding [ISO-IEC-8825-1] of the underlying GSS-API mechanism's OID. Base64 encoding is described in [Section 6.8 of \[RFC2045\]](#).



## Family method references

Family Name prefix	Hash Function	Parameters / Function Name	Definition
gss-nistp256-sha256-	SHA-256	secp256r1	<a href="#">Section 2.4.2</a> of <a href="#">[SEC2v2]</a>
gss-nistp384-sha384-	SHA-384	secp384r1	<a href="#">Section 2.5.1</a> of <a href="#">[SEC2v2]</a>
gss-nistp521-sha512-	SHA-512	secp521r1	<a href="#">Section 2.6.1</a> of <a href="#">[SEC2v2]</a>
gss-curve25519-sha256-	SHA-256	X25519	<a href="#">Section 5</a> of <a href="#">[RFC7748]</a>
gss-curve448-sha512-	SHA-512	X448	<a href="#">Section 5</a> of <a href="#">[RFC7748]</a>

## 6. IANA Considerations

This document augments the SSH Key Exchange Method Names in [\[RFC4462\]](#).

IANA is requested to update the SSH Protocol Parameters [\[IANA-KEX-NAMES\]](#) registry with the following entries:

Key Exchange Method Name	Reference	Implementation Support
gss-group14-sha256-*	This draft	SHOULD
gss-group15-sha512-*	This draft	MAY
gss-group16-sha512-*	This draft	SHOULD
gss-group17-sha512-*	This draft	MAY
gss-group18-sha512-*	This draft	MAY
gss-nistp256-sha256-*	This draft	SHOULD
gss-nistp384-sha384-*	This draft	MAY
gss-nistp521-sha512-*	This draft	MAY
gss-curve25519-sha256-*	This draft	SHOULD
gss-curve448-sha512-*	This draft	MAY

## 7. Security Considerations

### 7.1. New Finite Field DH mechanisms

Except for the use of a different secure hash function and larger DH groups, no significant changes has been made to the protocol





described by [RFC4462]; therefore all the original Security Considerations apply.

### **7.2. New Elliptic Curve DH mechanisms**

Although a new cryptographic primitive is used with these methods the actual key exchange closely follows the key exchange defined in [RFC5656]; therefore all the original Security Considerations as well as those expressed in [RFC5656] apply.

### **7.3. GSSAPI Delegation**

Some GSSAPI mechanisms can optionally delegate credentials to the target host by setting the `deleg_ret_flag`. In this case extra care must be taken to ensure that the acceptor being authenticated matches the target the user intended. Some mechanisms implementations (like commonly used `krb5` libraries) may use insecure DNS resolution to canonicalize the target name; in these cases spoofing a DNS response that points to an attacker-controlled machine may results in the user silently delegating credentials to the attacker, who can then impersonate the user at will.

## **8. References**

### **8.1. Normative References**

- [I-D.ietf-curdle-ssh-curves]  
Adamantiadis, A., Josefsson, S., and M. Baushke, "Secure Shell (SSH) Key Exchange Method using Curve25519 and Curve448", [draft-ietf-curdle-ssh-curves-07](#) (work in progress), January 2018.
- [RFC1321] Rivest, R., "The MD5 Message-Digest Algorithm", [RFC 1321](#), DOI 10.17487/RFC1321, April 1992, <https://www.rfc-editor.org/info/rfc1321>.
- [RFC2045] Freed, N. and N. Borenstein, "Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies", [RFC 2045](#), DOI 10.17487/RFC2045, November 1996, <https://www.rfc-editor.org/info/rfc2045>.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.



- [RFC3526] Kivinen, T. and M. Kojo, "More Modular Exponential (MODP) Diffie-Hellman groups for Internet Key Exchange (IKE)", [RFC 3526](#), DOI 10.17487/RFC3526, May 2003, <<https://www.rfc-editor.org/info/rfc3526>>.
- [RFC4462] Hutzelman, J., Salowey, J., Galbraith, J., and V. Welch, "Generic Security Service Application Program Interface (GSS-API) Authentication and Key Exchange for the Secure Shell (SSH) Protocol", [RFC 4462](#), DOI 10.17487/RFC4462, May 2006, <<https://www.rfc-editor.org/info/rfc4462>>.
- [RFC5656] Stebila, D. and J. Green, "Elliptic Curve Algorithm Integration in the Secure Shell Transport Layer", [RFC 5656](#), DOI 10.17487/RFC5656, December 2009, <<https://www.rfc-editor.org/info/rfc5656>>.
- [RFC7546] Kaduk, B., "Structure of the Generic Security Service (GSS) Negotiation Loop", [RFC 7546](#), DOI 10.17487/RFC7546, May 2015, <<https://www.rfc-editor.org/info/rfc7546>>.
- [RFC7748] Langley, A., Hamburg, M., and S. Turner, "Elliptic Curves for Security", [RFC 7748](#), DOI 10.17487/RFC7748, January 2016, <<https://www.rfc-editor.org/info/rfc7748>>.
- [SEC1v2] Certicom Research, "SEC 1: Elliptic Curve Cryptography", Standards for Efficient Cryptography SEC 1, Version 2.0, 2009.
- [SEC2v2] Certicom Research, "SEC 2: Recommended Elliptic Curve Domain Parameters", Standards for Efficient Cryptography SEC 2, Version 2.0, 2010.

## **8.2. Informative References**

- [IANA-KEX-NAMES] Internet Assigned Numbers Authority, "Secure Shell (SSH) Protocol Parameters: Key Exchange Method Names", June 2005, <<https://www.iana.org/assignments/ssh-parameters/ssh-parameters.xhtml#ssh-parameters-16>>.
- [ISO-IEC-8825-1] International Organization for Standardization / International Electrotechnical Commission, "ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)", ISO/IEC 8825-1, November 2015, <[http://standards.iso.org/ittf/PubliclyAvailableStandards/c068345\\_ISO\\_IEC\\_8825-1\\_2015.zip](http://standards.iso.org/ittf/PubliclyAvailableStandards/c068345_ISO_IEC_8825-1_2015.zip)>.



## [NIST-SP-800-131Ar1]

National Institute of Standards and Technology,  
"Transitions: Recommendation for Transitioning of the Use  
of Cryptographic Algorithms and Key Lengths", NIST Special  
Publication 800-131A Revision 1, November 2015,  
<[http://nvlpubs.nist.gov/nistpubs/SpecialPublications/  
NIST.SP.800-131Ar1.pdf](http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-131Ar1.pdf)>.

[RFC6194] Polk, T., Chen, L., Turner, S., and P. Hoffman, "Security  
Considerations for the SHA-0 and SHA-1 Message-Digest  
Algorithms", [RFC 6194](#), DOI 10.17487/RFC6194, March 2011,  
<<https://www.rfc-editor.org/info/rfc6194>>.

[RFC6234] Eastlake 3rd, D. and T. Hansen, "US Secure Hash Algorithms  
(SHA and SHA-based HMAC and HKDF)", [RFC 6234](#),  
DOI 10.17487/RFC6234, May 2011,  
<<https://www.rfc-editor.org/info/rfc6234>>.

[RFC8268] Baushke, M., "More Modular Exponentiation (MODP) Diffie-  
Hellman (DH) Key Exchange (KEX) Groups for Secure Shell  
(SSH)", [RFC 8268](#), DOI 10.17487/RFC8268, December 2017,  
<<https://www.rfc-editor.org/info/rfc8268>>.

## Authors' Addresses

Simo Sorce  
Red Hat, Inc.  
140 Broadway  
24th Floor  
New York, NY 10025  
USA

Email: [simo@redhat.com](mailto:simo@redhat.com)

Hubert Kario  
Red Hat, Inc.  
Purkynova 115  
Brno 602 00  
Czech Republic

Email: [hkario@redhat.com](mailto:hkario@redhat.com)

