   **Key Exchange (KEX) Method Updates and Recommendations for Secure Shell
                              (SSH)
                draft-ietf-curdle-ssh-kex-sha2-03**

Abstract

   This document adds recommendations for adoption of ssh-curves from
   the [I-D.ietf-curdle-ssh-curves], adds some new Modular Exponential
   (MODP) Groups, and deprecates some previously specified Key Exchange
   Method algorithm names for the Secure Shell (SSH) protocol. It also
   updates [RFC4253], [RFC4419], [RFC4462], and [RFC5656] by specifying
   the set key exchange algorithms that currently exist and which ones
   MUST, SHOULD, MAY, and SHOULD NOT be implemented. New key exchange
   methods use the SHA-2 family of hashes.

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   provisions of BCP 78 and BCP 79.

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1. Overview and Rationale

Secure Shell (SSH) is a common protocol for secure communication on the Internet. In [RFC4253], SSH originally defined the Key Exchange Method Name diffie-hellman-group1-sha1 which used [RFC2409] Oakley Group 1 (a MODP group with 768 bits) and SHA-1 [RFC3174]. Due to recent security concerns with SHA-1 [RFC6194] and with MODP groups with less than 2048 bits [NIST-SP-800-131Ar1] implementer and users request support for larger MODP group sizes with data integrity verification using the SHA-2 family of secure hash algorithms as well as MODP groups providing more security.

The United States Information Assurance Directorate (IAD) at the National Security Agency (NSA) has published a FAQ [MFQ-U-OO-815099-15] suggesting that the use of Elliptic Curve Diffie-Hellman (ECDH) using the nistp256 curve and SHA-2 based hashes less than SHA2-384 are no longer sufficient for transport of Top Secret information. It is for this reason that this draft moves ecdh-sha2-nistp256 from a REQUIRED to OPTIONAL as a key exchange method. This is the same reason that the stronger MODP groups being introduced are using SHA2-512 as the hash algorithm. Group14 is already present in most SSH implementations and most implementations already have a SHA2-256 implementation, so diffie-hellman-group14-sha256 is provided as an easy to implement and faster to use key exchange for small embedded applications.

It has been observed in [safe-curves] that the NIST recommended Elliptic Curve Prime Curves (P-256, P-384, and P-521) are perhaps not the best available for Elliptic Curve Cryptography (ECC) Security. For this reason, none of the [RFC5656] curves are marked as a MUST implement. However, the requirement that "every compliant SSH ECC implementation MUST implement ECDH key exchange" is now taken to mean that if ecdsa-sha2-[identifier] is implemented, then ecdh-sha2-[identifier] MUST be implemented.

Please send comments on this draft to curdle@ietf.org.

2. Requirements Language

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].

3. Key Exchange Algorithms

This memo adopts the style and conventions of [RFC4253] in specifying
how the use of new data key exchange is indicated in SSH.

A new set of Elliptic Curve Diffie-Hellman ssh-curves exist. The
curve25519-sha256 MUST be adopted where possible.

As a hedge against uncertainty raised by the NSA IAD FAQ publication,
three new MODP Diffie-Hellman based key exchanges are proposed for
inclusion in the set of key exchange method names as well as the
curve448-sha512 curve.

The following new key exchange algorithms are defined:

```
Key Exchange Method Name          Note
diffie-hellman-group14-sha256     MAY/OPTIONAL
diffie-hellman-group16-sha512     SHOULD/RECOMMENDED
diffie-hellman-group18-sha512     MAY/OPTIONAL
```

                            Figure 1

The SHA-2 family of secure hash algorithms are defined in
[FIPS-180-4].

The method of key exchange used for the name "diffie-hellman-
group14-sha256" is the same as that for "diffie-hellman-group14-sha1"
except that the SHA2-256 hash algorithm is used.

The group16 and group18 names are the same as those specified in
[RFC3526] 4096-bit MODP Group 16 and 8192-bit MODP Group 18.

The SHA2-512 algorithm is to be used when "sha512" is specified as a
part of the key exchange method name.

4. IANA Considerations

This document augments the Key Exchange Method Names in [RFC4253].
It downgrades the use of SHA-1 hashing for key exchange methods in
[RFC4419], [RFC4432], and [RFC4462]. It also moves from MUST to MAY
the ecdh-sha2-nistp256 given in [RFC5656].

It is desirable to also include the ssh-curves from the
[I-D.ietf-curdle-ssh-curves] in this list. The "curve25519-sha256"
is currently available in some Secure Shell implementations under the
name "curve25519-sha256@libssh.org" and is the best candidate for a
fast, safe, and secure key exchange method.

IANA is requested to update the SSH algorithm registry with the
following entries:

Key Exchange Method Name	Reference	Note
diffie-hellman-group-exchange-sha1	RFC4419	SHOULD NOT
diffie-hellman-group-exchange-sha256	RFC4419	MAY
diffie-hellman-group1-sha1	RFC4253	SHOULD NOT
diffie-hellman-group14-sha1	RFC4253	SHOULD
ecdh-sha2-nistp256	RFC5656	MAY
ecdh-sha2-nistp384	RFC5656	SHOULD
ecdh-sha2-nistp521	RFC5656	SHOULD
ecdh-sha2-*	RFC5656	MAY
ecmqv-sha2	RFC5656	MAY
gss-gex-sha1-*	RFC4462	SHOULD NOT
gss-group1-sha1-*	RFC4462	SHOULD NOT
gss-group14-sha1-*	RFC4462	MAY
gss-*	RFC4462	MAY
rsa1024-sha1	RFC4432	SHOULD NOT
rsa2048-sha256	RFC4432	MAY
diffie-hellman-group14-sha256	This Draft	MAY
diffie-hellman-group16-sha512	This Draft	SHOULD
diffie-hellman-group18-sha512	This Draft	MAY
curve25519-sha256	ssh-curves	MUST
curve448-sha512	ssh-curves	MAY

Figure 2

The Note in the above table is an implementation suggestion/
recommendation for the listed key exchange method. It is up to the
end-user as to what algorithms they choose to be able to negotiate.

The guidance of his document is that the SHA-1 algorithm hashing
SHOULD NOT be used. If it is used, it should only be provided for
backwards compatibility, should not be used in new designs, and
should be phased out of existing key exchanges as quickly as possible
because of its known weaknesses. Any key exchange using SHA-1 SHOULD
NOT be in a default key exchange list if at all possible. If they
are needed for backward compatibility, they SHOULD be listed after
all of the SHA-2 based key exchanges.

The RFC4253 REQUIRED diffie-hellman-group14-sha1 method SHOULD be
retained for compatibility with older Secure Shell implementations.

It is intended that this key exchange be phased out as soon as
possible.

5. Acknowledgements

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Kouichi, Simon Josefsson, Dave Dugal, Daniel Migault.

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exchanges using some of these groups as found in an this draft:
Darren Tucker for OpenSSH and Matt Johnston for Dropbear. And thanks
to Iwamoto Kouichi for information about RLogin, Tera Term (ttssh)
and Poderosa implementations also adopting new Diffie-Hellman groups
based on this draft.

6. Security Considerations

The security considerations of [RFC4253] apply to this document.

The security considerations of [RFC3526] suggest that these MODP
groups have security strengths given in this table. They are based
on [RFC3766] Determining Strengths For Public Keys Used For
Exchanging Symmetric Keys.

Group modulus security strength estimates (RFC3526)

```
+--------+----------+--------------------+--------------------+
| Group  | Modulus  | Strength Estimate 1 | Strength Estimate 2 |
|        |          +----------+----------+----------+----------+
|        |          |          | exponent |          | exponent |
|        |          | in bits  | size     | in bits  | size     |
+--------+----------+----------+----------+----------+----------+
| 14     | 2048-bit |      110 |     220- |      160 |     320- |
| 15     | 3072-bit |      130 |     260- |      210 |     420- |
| 16     | 4096-bit |      150 |     300- |      240 |     480- |
| 17     | 6144-bit |      170 |     340- |      270 |     540- |
| 18     | 8192-bit |      190 |     380- |      310 |     620- |
+--------+----------+--------------------+--------------------+
```

Figure 3

Many users seem to be interested in the perceived safety of using
larger MODP groups and hashing with SHA2-based algorithms.

7. References

7.1. Normative References

   [FIPS-180-4]
             National Institute of Standards and Technology, "Secure
             Hash Standard (SHS)", FIPS PUB 180-4, August 2015,
             <http://nvlpubs.nist.gov/nistpubs/FIPS/
             NIST.FIPS.180-4.pdf>.

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
             Requirement Levels", BCP 14, RFC 2119,
             DOI 10.17487/RFC2119, March 1997,
             <http://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,
             <http://www.rfc-editor.org/info/rfc3526>.

   [RFC4253] Ylonen, T. and C. Lonvick, Ed., "The Secure Shell (SSH)
             Transport Layer Protocol", RFC 4253, DOI 10.17487/RFC4253,
             January 2006, <http://www.rfc-editor.org/info/rfc4253>.

7.2. Informative References

   [I-D.ietf-curdle-ssh-curves]
             Adamantiadis, A. and S. Josefsson, "Secure Shell (SSH) Key
             Exchange Method using Curve25519 and Curve448", draft-
             ietf-curdle-ssh-curves-00 (work in progress), March 2016.

   [MFQ-U-OO-815099-15]
             "National Security Agency/Central Security Service", "CNSA
             Suite and Quantum Computing FAQ", January 2016,
             <https://www.iad.gov/iad/library/ia-guidance/ia-solutions-
             for-classified/algorithm-guidance/cnsa-suite-and-quantum-
             computing-faq.cfm>.

   [NIST-SP-800-131Ar1]
             Barker, and Roginsky, "Transitions: Recommendation for the
             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>.

[RFC2409]   Harkins, D. and D. Carrel, "The Internet Key Exchange
            (IKE)", RFC 2409, DOI 10.17487/RFC2409, November 1998,
            <http://www.rfc-editor.org/info/rfc2409>.

[RFC3174]   Eastlake 3rd, D. and P. Jones, "US Secure Hash Algorithm 1
            (SHA1)", RFC 3174, DOI 10.17487/RFC3174, September 2001,
            <http://www.rfc-editor.org/info/rfc3174>.

[RFC3766]   Orman, H. and P. Hoffman, "Determining Strengths For
            Public Keys Used For Exchanging Symmetric Keys", BCP 86,
            RFC 3766, DOI 10.17487/RFC3766, April 2004,
            <http://www.rfc-editor.org/info/rfc3766>.

[RFC4419]   Friedl, M., Provos, N., and W. Simpson, "Diffie-Hellman
            Group Exchange for the Secure Shell (SSH) Transport Layer
            Protocol", RFC 4419, DOI 10.17487/RFC4419, March 2006,
            <http://www.rfc-editor.org/info/rfc4419>.

[RFC4432]   Harris, B., "RSA Key Exchange for the Secure Shell (SSH)
            Transport Layer Protocol", RFC 4432, DOI 10.17487/RFC4432,
            March 2006, <http://www.rfc-editor.org/info/rfc4432>.

[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, <http://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,
            <http://www.rfc-editor.org/info/rfc5656>.

[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,
            <http://www.rfc-editor.org/info/rfc6194>.

[safe-curves]
            Bernstein, and Lange, "SafeCurves: choosing safe curves
            for elliptic-curve cryptography.", February 2016,
            <https://safecurves.cr.yp.to/>.

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