

Internet Engineering Task Force (IETF)
Request for Comments: 9987
Category: Standards Track
ISSN: 2070-1721

D. Miller
OpenSSH
May 2026

Secure Shell (SSH) Agent Protocol

Abstract

This document specifies a key agent protocol for use in the Secure Shell (SSH) protocol.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at <https://www.rfc-editor.org/info/rfc9987>.

Copyright Notice

Copyright (c) 2026 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 Revised BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Revised BSD License.

Table of Contents

1. Introduction
2. Requirements Language
3. Protocol Overview
4. Terminology and Units
5. Protocol Messages
 - 5.1. Generic Agent Responses
 - 5.2. Adding Keys to the Agent
 - 5.2.1. DSA Keys
 - 5.2.2. ECDSA Keys
 - 5.2.3. EdDSA Keys
 - 5.2.4. RSA Keys
 - 5.2.5. Other Keys
 - 5.2.6. Adding Keys from a Token
 - 5.2.7. Key Constraints
 - 5.3. Public Key Encoding
 - 5.4. Removing Keys from the Agent
 - 5.5. Requesting a List of Keys
 - 5.6. Private Key Operations

5.6.1.	Signature Flags
5.7.	Locking and Unlocking an Agent
5.8.	Extension Mechanism
5.8.1.	Query Extension
6.	Connecting to an Agent
7.	Forwarding Access to an Agent
7.1.	Advertising Agent Forwarding Support
7.2.	Requesting Agent Forwarding
7.3.	Agent Connection Requests
8.	Protocol Numbers
8.1.	Message Type Numbers
8.1.1.	Reserved Message Type Numbers
8.2.	Constraint Identifiers
8.3.	Signature Flags
9.	IANA Considerations
9.1.	Guidance for Designated Experts
9.2.	"SSH Agent Protocol Message Type Numbers" Registry
9.3.	"SSH Agent Key Constraint Numbers" Registry
9.4.	"SSH Agent Key Constraint Extension Names" Registry
9.5.	"SSH Agent Signature Flags" Registry
9.6.	"SSH Agent Extension Request Names" Registry
9.7.	Additions to the "Extension Names" Registry
9.8.	Additions to the "Connection Protocol Channel Request Names" Registry
9.9.	Additions to the "Connection Protocol Channel Types" Registry
10.	Security Considerations
11.	References
11.1.	Normative References
11.2.	Informative References
	Acknowledgments
	Author's Address

1. Introduction

Secure Shell (SSH) [RFC4251] is a protocol for secure remote connections [RFC4253] and login [RFC4254] over untrusted networks. It supports multiple authentication mechanisms [RFC4252] including public key authentication. This document specifies the protocol for interacting with a key management component, usually referred to as "an agent", that holds private keys. SSH clients (and possibly SSH servers) can invoke the agent via this protocol to perform operations using public and private keys held in the agent.

Holding keys in an agent offers usability and security advantages to loading and unwrapping them at each use, as each key unwrapping may require entry of a passphrase. Access to an agent may optionally be forwarded across an SSH connection, thereby allowing remote systems to use stored keys without directly exposing the key material to the remote system. Finally, the agent may be implemented as a dedicated component that presents a smaller attack surface than a key loaded into a full SSH server or client and that may be subject to special protection from the wider system.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Protocol Overview

The agent protocol is a packetised request-response protocol that is solely driven by the client. It consists of a number of requests

sent from a client to an agent and a set of reply messages that are sent in response. At no time does the agent send messages except in response to a client request. Replies are sent in order.

These requests include the ability to load keys into an agent, remove some or all keys from an agent, and perform signature operations using previously loaded keys.

Agents MAY implement support for only a subset of available key types and MAY additionally refuse some operations in particular contexts. For example, an agent may allow only clients local to itself to add keys or may make particular subsets of keys available to a given client. For this reason, clients of the agent SHOULD be prepared to fail gracefully if any operation is refused.

4. Terminology and Units

Henceforth, in this document, "agent" will be used to refer to a key management component that implements the responder side of this protocol. "Client" will refer to a tool that implements the requester side of the protocol to communicate with an agent. If it is pertinent that the client in question is a Secure Shell client as described in [RFC4251], then the client will be explicitly referred to as an "SSH client". Similarly, "SSH server" will be used to refer to Secure Shell servers.

All encoding data types ("byte", "uint32", "string", etc.) are as specified in Section 5 of [RFC4251]. Additionally, the type "byte[]" without a specified length within the square brackets indicates an unadorned sequence of zero or more bytes where the length is determined by context.

All length units are given in bytes unless otherwise specified.

5. Protocol Messages

Messages consist of a "length", "type", and "contents".

uint32	length
byte	type
byte[length - 1]	contents

In the sections below, the "length" field is omitted. For clarity, the symbolic names of the message types are shown; their numeric values are listed in Section 8.1.

5.1. Generic Agent Responses

The following generic messages may be sent by the agent in response to requests from the client. On success, the agent MUST reply either with the single-byte response:

byte	SSH_AGENT_SUCCESS
------	-------------------

or with a request-specific success message that may contain additional fields. On failure, the agent MUST reply with the single-byte response:

byte	SSH_AGENT_FAILURE
------	-------------------

or with a request-specific failure message that may contain additional fields. SSH_AGENT_FAILURE messages MUST also be sent in reply to requests with unknown or unsupported types.

5.2. Adding Keys to the Agent

Keys may be added to the agent using the `SSH_AGENTC_ADD_IDENTITY` or `SSH_AGENTC_ADD_ID_CONSTRAINED` messages. The latter variant allows adding keys with optional constraints on their usage.

The generic format for the `SSH_AGENTC_ADD_IDENTITY` message is:

byte	<code>SSH_AGENTC_ADD_IDENTITY</code>
string	key type
byte[]	key data
string	comment

Here "key type" is the specified key type name, for example, "ssh-rsa" for an RSA key as defined by [RFC4253]. The "key data" consists of the public and private components of the key and varies by key type, as specified in Sections 5.2.1 through 5.2.4 for commonly used key types. A "comment" is a human-readable key name or comment as a UTF-8 string that may serve to identify the key in user-visible messages. This string may be of zero length.

The `SSH_AGENTC_ADD_ID_CONSTRAINED` message is similar but adds an extra field:

byte	<code>SSH_AGENTC_ADD_ID_CONSTRAINED</code>
string	key type
byte[]	key data
string	comment
constraint[]	constraints

Constraints are used to place limits on the validity or use of keys. Section 5.2.7 details constraint types and their formats. Clients SHOULD prefer the `SSH_AGENTC_ADD_IDENTITY` message over sending an `SSH_AGENTC_ADD_ID_CONSTRAINED` message with an empty "constraints" field, though both are valid and equivalent.

An agent MUST reply with `SSH_AGENT_SUCCESS` if the key was successfully loaded as a result of one of these messages or `SSH_AGENT_FAILURE` otherwise.

Adding a key that is already present in an agent SHOULD replace any constraints it was previously loaded with those (if any) that are present in the subsequent add request, as this ensures that security-relevant constraints on a loaded key best match user expectations. Otherwise, an agent MAY refuse to load a key that has already been loaded.

An agent MAY support only a subset of the key types defined here and MAY support additional key types as described below. If an agent does not recognise the type name in a request to add a key, then it MUST respond with an `SSH_AGENT_FAILURE` reply.

5.2.1. DSA Keys

Digital Signature Algorithm (DSA) keys have key type name "ssh-dss" and are defined in [RFC4253]. They may be added to the agent using the following message. The "constraints" field is only present for the `SSH_AGENTC_ADD_ID_CONSTRAINED` message.

byte	<code>SSH_AGENTC_ADD_IDENTITY</code> or <code>SSH_AGENTC_ADD_ID_CONSTRAINED</code>
string	"ssh-dss"
mpint	p
mpint	q
mpint	g
mpint	y
mpint	x
string	comment

constraint[] constraints

The "p", "q", and "g" values are the DSA domain parameters. The "y" and "x" values are the public and private keys, respectively. These values are as defined by Section 4.1 of [FIPS.186-4].

5.2.2. ECDSA Keys

Elliptic Curve Digital Signature Algorithm (ECDSA) keys have key types starting with "ecdsa-sha2-" and are defined in [RFC5656]. They may be added to the agent using the following message. The "constraints" field is only present for the SSH_AGENTC_ADD_ID_CONSTRAINED message.

byte	SSH_AGENTC_ADD_IDENTITY or SSH_AGENTC_ADD_ID_CONSTRAINED
string	key type
string	ecdsa_curve_name
string	Q
mpint	d
string	comment
constraint[]	constraints

The values "Q" and "d" are the ECDSA public and private values respectively. Both are defined by Section 6.2 of [FIPS.186-5].

5.2.3. EdDSA Keys

[RFC8709] defines Edwards-curve Digital Signature Algorithm (EdDSA) keys (see [RFC8032]) Ed25519 and Ed448 with key type names "ssh-ed25519" and "ssh-ed448", respectively. These may be added to the agent using the following message. The "constraints" field is only present for the SSH_AGENTC_ADD_ID_CONSTRAINED message.

byte	SSH_AGENTC_ADD_IDENTITY or SSH_AGENTC_ADD_ID_CONSTRAINED
string	"ssh-ed25519" or "ssh-ed448"
string	ENC(A)
string	k ENC(A)
string	comment
constraint[]	constraints

The first value is the EdDSA public key ENC(A). The second value is a concatenation of the private key k and the public ENC(A) key (this repetition of the public key is to maintain compatibility with widely deployed implementations). The contents and interpretation of the ENC(A) and k values are defined by Section 3.2 of [RFC8032].

5.2.4. RSA Keys

RSA keys have key type name "ssh-rsa" and are defined in [RFC4253]. They may be added to the agent using the following message. The "constraints" field is only present for the SSH_AGENTC_ADD_ID_CONSTRAINED message.

byte	SSH_AGENTC_ADD_IDENTITY or SSH_AGENTC_ADD_ID_CONSTRAINED
string	"ssh-rsa"
mpint	n
mpint	e
mpint	d
mpint	iqmp
mpint	p
mpint	q
string	comment
constraint[]	constraints

"n" is the public composite modulus. "e" is the public exponent. "d" is the private exponent. "p" and "q" are its constituent private prime factors. "iqmp" is the inverse of "q" modulo "p". All of these values, except "iqmp" (which can be calculated from the others), are defined by Section 5.1 of [FIPS.186-5].

5.2.5. Other Keys

Agents and their clients MAY support additional key types not documented here. Vendor-specific key types MUST use the domain-qualified naming convention defined in Section 6 of [RFC4251] until codepoints are allocated by IANA [IANA-PUBKEYS].

5.2.6. Adding Keys from a Token

Keys hosted on smart-cards or other hardware tokens may be added using the `SSH_AGENTC_ADD_SMARTCARD_KEY` and `SSH_AGENTC_ADD_SMARTCARD_KEY_CONSTRAINED` requests. Note that the "constraints" field is only included for the `SSH_AGENTC_ADD_SMARTCARD_KEY_CONSTRAINED` variant of this message.

byte	<code>SSH_AGENTC_ADD_SMARTCARD_KEY</code> or <code>SSH_AGENTC_ADD_SMARTCARD_KEY_CONSTRAINED</code>
string	token id
string	PIN
constraint[]	constraints

Here "token id" is an opaque identifier for the hardware token and "PIN" is an optional password or PIN to unlock the key. The interpretation of "token id" is not defined by the protocol: it is left solely up to the agent.

Typically, only the public components of any keys supported on a hardware token will be loaded into an agent; thus, strictly speaking, this message really arranges for future private key operations to be delegated to the hardware token in question.

An agent MUST reply with `SSH_AGENT_SUCCESS` if one or more keys were successfully loaded as a result of one of these messages or with `SSH_AGENT_FAILURE` if no keys were found. The agent MUST also return `SSH_AGENT_FAILURE` if the "token id" was not recognised, if the request was against agent policy, or if the agent doesn't support token-hosted keys at all.

5.2.7. Key Constraints

A number of constraints may be used in the constrained variants of the key add messages. Each constraint is represented by a type byte followed by zero or more value bytes.

Zero or more constraints may be specified when adding a key with one of the *_CONSTRAINED requests. Multiple constraints are appended consecutively to the end of the request:

byte	constraint1_type
byte[]	constraint1_data
byte	constraint2_type
byte[]	constraint2_data
....	
byte	constraintN_type
byte[]	constraintN_data

To fully parse a constraint, it is necessary to know its structure beforehand; it is not possible to safely recover when an unrecognised constraint is encountered. Given this, if an agent does not

recognise or support a requested constraint, it MUST abort parsing, refuse the request, and return an SSH_AGENT_FAILURE message to the client.

The following subsections describe the constraints that have been defined.

5.2.7.1. Key Lifetime Constraint

This constraint requests that the agent limit the key's lifetime by deleting it after the specified duration (in seconds) has elapsed from the time the key was added to the agent.

byte	SSH_AGENT_CONSTRAIN_LIFETIME
uint32	seconds

5.2.7.2. Key Confirmation Constraint

This constraint requests that the agent require explicit user confirmation for each private key operation using the key. For example, the agent could present a confirmation dialog before completing a signature operation.

byte	SSH_AGENT_CONSTRAIN_CONFIRM
------	-----------------------------

5.2.7.3. Constraint Extensions

Agents may implement experimental or private-use constraints through an extension constraint that supports named constraints.

byte	SSH_AGENT_CONSTRAIN_EXTENSION
string	extension name
byte[]	extension-specific details

The "extension name" MUST consist of a UTF-8 string. Vendor extensions MUST be suffixed by the implementation domain following the naming scheme defined in Section 6 of [RFC4251], e.g., "foo@example.com".

Note, given the above requirement to reject keys with unsupported constraints, a constraint extension is only usable when both the client and agent support it. Otherwise, the agent will be required to reject the key. This is desirable, as the constraint extension may specify limits on the key that, if ignored, may result in the key being available in situations the user did not intend (i.e., the agent will fail safely).

5.3. Public Key Encoding

Keys previously loaded into an agent are referred to by their public key blob, which is the standard SSH wire encoding for public keys. SSH protocol key encodings are defined in [RFC4253] for "ssh-rsa" and "ssh-dss" keys, in [RFC5656] for "ecdsa-sha2-*" keys, and in [RFC8709] for "ssh-ed25519" and "ssh-ed448" keys.

5.4. Removing Keys from the Agent

A client may request that an agent remove all keys that it stores:

byte	SSH_AGENTC_REMOVE_ALL_IDENTITYIES
------	-----------------------------------

On receipt of such a message, an agent SHOULD delete all keys that it is holding and reply with SSH_AGENT_SUCCESS; otherwise, it MUST reply with SSH_AGENT_FAILURE if the request was refused.

This request SHOULD be honoured regardless of any agent policy that

limits actions that a given client may take; otherwise, a user would be unable to quickly and completely remove their keys in an urgent situation.

Specific keys may also be removed:

byte	SSH_AGENTC_REMOVE_IDENTITY
string	key blob

Where "key blob" is the standard public key encoding of the key to be removed (Section 5.3).

An agent MUST reply with SSH_AGENT_SUCCESS if the key was deleted or SSH_AGENT_FAILURE if it was not found.

Token-hosted keys may be removed from an agent using:

byte	SSH_AGENTC_REMOVE_SMARTCARD_KEY
string	token id
string	PIN

Where "token id" is an opaque identifier for the hardware token and "PIN" is an optional password or PIN (not typically used), both encoded using UTF-8. Requesting deletion of token-hosted keys SHOULD cause the agent to remove all keys it loaded from the device matching "token id". Similarly to SSH_AGENTC_REMOVE_ALL_IDENTITY, agents SHOULD honour this request regardless of local policy to allow fast and complete removal of keys. Removing a token-hosted key affects the agent only; it SHOULD NOT cause the keys be deleted from the token itself.

An agent MUST reply with SSH_AGENT_SUCCESS if the keys were deleted or SSH_AGENT_FAILURE if none were found.

5.5. Requesting a List of Keys

A client may request a list of keys from an agent using the following message:

byte	SSH_AGENTC_REQUEST_IDENTITY
------	-----------------------------

The agent MUST reply with a message with the following preamble:

byte	SSH_AGENT_IDENTITY_ANSWER
uint32	nkeys

Where "nkeys" indicates the number of keys to follow. Following the preamble are zero or more keys, representing the keys the agent makes available to the client with each encoded as:

string	key blob
string	comment

Where "key blob" is the standard public key encoding of the key (Section 5.3) and "comment" is a human-readable comment encoded as a UTF-8 string.

5.6. Private Key Operations

A client may request that the agent perform a private key signature operation using the following message:

byte	SSH_AGENTC_SIGN_REQUEST
string	key blob
string	data
uint32	flags

Where "key blob" is the key requested to perform the signature (encoded as per Section 5.3), "data" is the data to be signed, and "flags" is a bitfield containing the bitwise OR of zero or more signature flags (see below).

If the agent does not support the requested flags, or is otherwise unable or unwilling to generate the signature (for example, because it doesn't have the specified key or the user refused confirmation of a constrained key), it MUST reply with an SSH_AGENT_FAILURE message.

On success, the agent MUST reply with:

byte	SSH_AGENT_SIGN_RESPONSE
string	signature

The signature format is specific to the algorithm of the key type in use. SSH protocol signature formats are defined in [RFC4253] for "ssh-rsa" and "ssh-dss" keys, in [RFC5656] for "ecdsa-sha2-*" keys, and in [RFC8709] for "ssh-ed25519" and "ssh-ed448" keys.

5.6.1. Signature Flags

Two flags are currently defined for signature request messages: SSH_AGENT_RSA_SHA2_256 and SSH_AGENT_RSA_SHA2_512 (defined in Section 8.3). These two flags are only valid for "ssh-rsa" keys and request that the agent return a signature using the "rsa-sha2-256" or "rsa-sha2-512" signature methods, respectively. These signature schemes are defined in [RFC8332].

5.7. Locking and Unlocking an Agent

The agent protocol supports instructing an agent to temporarily lock itself with a passphrase. When locked, an agent MUST suspend processing of sensitive operations (private key signature operations at the very least) until it has been unlocked with the same passphrase.

The following message instructs an agent to lock itself:

byte	SSH_AGENTC_LOCK
string	passphrase

The agent MUST reply with SSH_AGENT_SUCCESS if locked successfully or SSH_AGENT_FAILURE otherwise (e.g., if the agent was already locked).

The following message requests unlocking an agent:

byte	SSH_AGENTC_UNLOCK
string	passphrase

If the agent is already locked and the passphrase matches the one used to lock it, then it MUST unlock and reply with SSH_AGENT_SUCCESS. If the agent is already unlocked or if the passphrase does not match, it MUST reply with SSH_AGENT_FAILURE.

5.8. Extension Mechanism

The agent protocol includes an optional extension mechanism that allows vendor-specific and experimental messages to be sent via the agent protocol. Extension requests from the client consist of:

byte	SSH_AGENTC_EXTENSION
string	extension type
byte[]	extension request-specific contents

The "extension type" indicates the type of the extension message as a UTF-8 string. Implementation-specific extensions MUST be suffixed by the implementation domain following the extension naming scheme defined in Section 6 of [RFC4251], e.g., "foo@example.com".

An agent that does not support extensions of the supplied type MUST reply with an empty SSH_AGENT_FAILURE message. This reply is also sent by agents that do not support the extension mechanism at all.

The contents of successful extension reply messages are specific to the "extension type". Successful extension requests MUST return either SSH_AGENT_SUCCESS on success or an extension-specific response message:

byte	SSH_AGENT_EXTENSION_RESPONSE
string	extension type
byte[]	extension response-specific contents

Where the "extension type" is the same as that in the request.

Extension failure SHOULD be signaled using an SSH_AGENT_EXTENSION_FAILURE message:

byte	SSH_AGENT_EXTENSION_FAILURE
------	-----------------------------

Extensions SHOULD NOT use the standard SSH_AGENT_FAILURE message. This allows failed requests to be distinguished from the extension not being supported.

5.8.1. Query Extension

A single optional extension request "query" is defined to allow a client to query which, if any, extensions are supported by an agent.

byte	SSH_AGENTC_EXTENSION
string	"query"

If an agent supports the query extension, it SHOULD reply with a list of supported extension names.

byte	SSH_AGENT_EXTENSION_RESPONSE
string	"query"
string[]	supported extension types

6. Connecting to an Agent

Agents are exposed to the local system using a connection-oriented endpoint. On Unix-like systems, it is typical to arrange for the agent to listen on a filesystem-based Unix domain socket. On Microsoft Windows, it is usual to use a Windows Named Pipe. Access to these endpoints SHOULD be controlled as discussed in Section 10. Multiple clients may access a single agent by making connections to these sockets.

In both cases, it is common to expose the name or address of the listening endpoint via an environment variable named "SSH_AUTH_SOCK". Clients of an agent will use this variable to locate and connect to the listening agent. Alternatively, agents MAY use an implicit mechanism for clients to locate their endpoint, such as a default per-user location.

7. Forwarding Access to an Agent

Using the connection protocol described in [RFC4254], the agent protocol may be forwarded over an SSH connection. This allows agent forwarding to be requested for any session channel using a model that

is similar to the connection protocol's support for X11 Forwarding (Section 6.3 of [RFC4254]). This feature is OPTIONAL for the SSH protocol and agent implementations.

7.1. Advertising Agent Forwarding Support

Support for agent forwarding may be advertised by an SSH server using the extension mechanism described in [RFC8308] using the name "agent-forward" in the SSH_MSG_EXT_INFO message.

string	"agent-forward"
string	"0" (version)

Note that this protocol substantially predates the existence of the extension mechanism described in [RFC8308]. Further note that several widely deployed SSH implementations that support agent forwarding do not advertise their ability to do so. SSH clients MAY opportunistically attempt to request agent forwarding in the absence of an advertisement (see [RFC8308]) using the vendor-specific names mentioned below. Likewise, SSH servers MAY implement the vendor-specific names in addition to the one described here.

7.2. Requesting Agent Forwarding

An SSH client may request agent forwarding for a previously opened session (see Section 6.1 of [RFC4254]) using the following channel request. This request is sent after the channel has been opened, but before a shell, command, or subsystem has been executed.

byte	SSH_MSG_CHANNEL_REQUEST
uint32	channel_id
string	"agent-req" or "auth-agent-req@openssh.com"
boolean	want_reply

Where "channel_id" is the identifier for an established session channel (as returned from a previous SSH_MSG_CHANNEL_OPEN request) and the "want_reply" flag indicates whether the SSH server should respond with a confirmation of whether the request was successful (as specified in Section 5.4 of [RFC4254]).

If an SSH server accepts this request, typically it will arrange to make an endpoint (e.g., a listening socket) available and advertise this fact to the subordinate session. Most implementations on Unix-like systems do this by providing a user-private listening Unix domain socket and recording its location in an environment variable "SSH_AUTH_SOCK".

As mentioned previously, many deployed implementations only support the pre-standardisation "auth-agent-req@openssh.com" request name. The "agent-req" name SHOULD only be used if support was explicitly advertised as per Section 7.1.

7.3. Agent Connection Requests

After an SSH client has requested that a session have agent forwarding enabled, the SSH server may request a connection to the forwarded agent. The SSH server does this by requesting a dedicated channel to communicate with the SSH client's agent.

byte	SSH_MSG_CHANNEL_OPEN
string	"agent-connect" or "auth-agent@openssh.com"
uint32	channel_id
uint32	local_window
uint32	local_maxpacket

The "channel_id", "local_window", and "local_maxpacket" fields should

be interpreted as specified by Section 5.1 of [RFC4254].

As above, the "agent-connect" open type name SHOULD only be used if support was explicitly advertised as per Section 7.1.

An SSH client SHOULD be prepared to handle multiple concurrent forwarded connections to a client-side agent; otherwise, requests to access the agent from the remote side that happen to overlap prior requests may fail. Overlapping requests may occur because the SSH connection protocol [RFC4254] allows multiple user sessions over a single transport (see [RFC4253]), which may each request use of the agent independently and potentially concurrently.

An SSH client MAY accept agent connection requests (subject to authorisation) without a prior agent forwarding request having been made to support the situation where agent forwarding without opening a session is desired. Similarly, an SSH client MAY continue to accept agent connection requests after the session for which agent forwarding was requested has closed.

An SSH client MUST refuse unauthorised agent connection requests, when agent forwarding is neither requested nor desired by the SSH client but an SSH server sends an agent connection request anyway.

Because the "agent-connect" request contains no identifier to distinguish which session channel originated the connection request, an SSH connection can effectively forward access to only a single SSH client-side agent using this protocol (although there may be multiple concurrent connections to that single agent).

8. Protocol Numbers

8.1. Message Type Numbers

The following numbers are used as message types for requests from the client to the agent.

SSH_AGENTC_REQUEST_IDENTITIES	11
SSH_AGENTC_SIGN_REQUEST	13
SSH_AGENTC_ADD_IDENTITY	17
SSH_AGENTC_REMOVE_IDENTITY	18
SSH_AGENTC_REMOVE_ALL_IDENTITIES	19
SSH_AGENTC_ADD_SMARTCARD_KEY	20
SSH_AGENTC_REMOVE_SMARTCARD_KEY	21
SSH_AGENTC_LOCK	22
SSH_AGENTC_UNLOCK	23
SSH_AGENTC_ADD_ID_CONSTRAINED	25
SSH_AGENTC_ADD_SMARTCARD_KEY_CONSTRAINED	26
SSH_AGENTC_EXTENSION	27

Table 1

The following numbers are used as message types for replies from the

agent to the client.

SSH_AGENT_FAILURE	5
SSH_AGENT_SUCCESS	6
SSH_AGENT_IDENTITIES_ANSWER	12
SSH_AGENT_SIGN_RESPONSE	14
SSH_AGENT_EXTENSION_FAILURE	28
SSH_AGENT_EXTENSION_RESPONSE	29

Table 2

8.1.1. Reserved Message Type Numbers

The following message type numbers are reserved for implementations that implement support for the legacy SSH protocol version 1: 1-4, 7-10, 15-16, and 24 (inclusive). These message numbers MAY be used by an implementation supporting the legacy protocol but MUST NOT be reused otherwise.

Message number 0 is also reserved and MUST NOT be used.

The range of message numbers 240-255 is reserved for Private Use extensions to the agent protocol and MUST NOT be used by generic implementations (see [RFC8126] for more information on Private Use).

8.2. Constraint Identifiers

The following numbers are used to identify key constraints. These are only used in key constraints and are not sent as message numbers.

SSH_AGENT_CONSTRAIN_LIFETIME	1
SSH_AGENT_CONSTRAIN_CONFIRM	2
SSH_AGENT_CONSTRAIN_EXTENSION	255

Table 3

The constraint identifier 0 is reserved.

8.3. Signature Flags

The following numbers may be present in signature request (SSH_AGENTC_SIGN_REQUEST) messages. These flags form a bit field by taking the logical OR of zero or more flags.

SSH_AGENT_RSA_SHA2_256	0x00000002
SSH_AGENT_RSA_SHA2_512	0x00000004

Table 4

The flag value 1 is reserved for historical implementations.

9. IANA Considerations

This protocol describes the establishment of five registries: one for message type numbers, one for constraint numbers, one for signature request flags, one for constraint extension names, and one for extension request names. Additionally, new codepoints are requested in three existing registries.

9.1. Guidance for Designated Experts

When a Designated Expert (DE) is asked to review additions to the new registries described in this document (Section 9.2, Section 9.3, Section 9.5, and Section 9.6), they are requested to verify that suitable documentation as described in [RFC8126] exists and is permanently and publicly available. The DE is also requested to check the clarity of purpose and use of the requested codepoints. The DE should also verify that specifications produced in the IETF that request codepoints in these registries have been made available to the SSHM Working Group and the ssh@ietf.org mailing list for review. Requests for codepoints made for specifications produced outside the IETF should not conflict with active IETF work or prior IETF specifications.

The available number of codepoints in the SSH agent protocol numbers (Section 9.2), constraint numbers (Section 9.3), and SSH agent signature flags (Section 9.5) registries are limited, so the DE is requested to ensure the use of codepoints is very well justified. For the SSH agent protocol message numbers, named extension requests (Section 9.6) provide an alternative for most uses with no practical limitation on the number of available codepoints. For key constraint numbers, the constraint extension mechanism (Section 5.2.7.3) provides a similar alternative that is not limited by available codepoints.

9.2. "SSH Agent Protocol Message Type Numbers" Registry

The "SSH Agent Protocol Message Type Numbers" registry records the message type numbers for client requests and agent responses. It is located in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH]. Its initial state consists of the following numbers and reservations. Future message number allocations shall occur via Expert Review as per [RFC8126].

Number	Identifier	Reference
0	Reserved	RFC 9987, Section 8.1.1
1	Reserved	RFC 9987, Section 8.1.1
2	Reserved	RFC 9987, Section 8.1.1
3	Reserved	RFC 9987, Section 8.1.1
4	Reserved	RFC 9987, Section 8.1.1
5	SSH_AGENT_FAILURE	RFC 9987,

		Sections 5.1 and 8.1
6	SSH_AGENT_SUCCESS	RFC 9987, Sections 5.1 and 8.1
7	Reserved	RFC 9987, Section 8.1.1
8	Reserved	RFC 9987, Section 8.1.1
9	Reserved	RFC 9987, Section 8.1.1
10	Reserved	RFC 9987, Section 8.1.1
11	SSH_AGENTC_REQUEST_IDENTITIES	RFC 9987, Sections 5.5 and 8.1
12	SSH_AGENT_IDENTITIES_ANSWER	RFC 9987, Sections 5.5 and 8.1
13	SSH_AGENTC_SIGN_REQUEST	RFC 9987, Sections 5.6 and 8.1
14	SSH_AGENT_SIGN_RESPONSE	RFC 9987, Sections 5.6 and 8.1
15	Reserved	RFC 9987, Section 8.1.1
16	Reserved	RFC 9987, Section 8.1.1
17	SSH_AGENTC_ADD_IDENTITY	RFC 9987, Sections 5.2 and 8.1
18	SSH_AGENTC_REMOVE_IDENTITY	RFC 9987, Sections 5.4 and 8.1
19	SSH_AGENTC_REMOVE_ALL_IDENTITIES	RFC 9987, Sections 5.4 and 8.1
20	SSH_AGENTC_ADD_SMARTCARD_KEY	RFC 9987, Sections 5.2.6 and 8.1
21	SSH_AGENTC_REMOVE_SMARTCARD_KEY	RFC 9987, Sections

		5.4 and 8.1
22	SSH_AGENTC_LOCK	RFC 9987, Sections 5.7 and 8.1
23	SSH_AGENTC_UNLOCK	RFC 9987, Sections 5.7 and 8.1
24	Reserved	RFC 9987, Section 8.1.1
25	SSH_AGENTC_ADD_ID_CONSTRAINED	RFC 9987, Sections 5.2 and 8.1
26	SSH_AGENTC_ADD_SMARTCARD_KEY_CONSTRAINED	RFC 9987, Sections 5.2.6 and 8.1
27	SSH_AGENTC_EXTENSION	RFC 9987, Sections 5.8 and 8.1
28	SSH_AGENT_EXTENSION_FAILURE	RFC 9987, Sections 5.8 and 8.1
29	SSH_AGENT_EXTENSION_RESPONSE	RFC 9987, Sections 5.8 and 8.1
240-255	Private Use	RFC 9987, Section 8.1

Table 5

9.3. "SSH Agent Key Constraint Numbers" Registry

The "SSH Agent Key Constraint Numbers" registry records the message numbers for key use constraints. It is located in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH]. Its initial state is as follows. Future key constraint number allocations shall occur via Expert Review as per [RFC8126].

Number	Identifier	Reference
0	Reserved	RFC 9987, Section 8.2
1	SSH_AGENT_CONSTRAIN_LIFETIME	RFC 9987, Section 8.2
2	SSH_AGENT_CONSTRAIN_CONFIRM	RFC 9987, Section 8.2
255	SSH_AGENT_CONSTRAIN_EXTENSION	RFC 9987, Section 8.2

Table 6

9.4. "SSH Agent Key Constraint Extension Names" Registry

The "SSH Agent Key Constraint Extension Names" registry records the

names used in the SSH_AGENT_CONSTRAIN_EXTENSION constraint extension type (Section 5.2.7.3). It is located in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH]. Its initial state is empty. Future key constraint extension name allocations shall occur via Expert Review as per [RFC8126].

9.5. "SSH Agent Signature Flags" Registry

The "SSH Agent Signature Flags" registry records the values for signature request (SSH_AGENTC_SIGN_REQUEST) flag values. It is located in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH]. Its initial state consists of the following numbers. Note that as the flags are combined by bitwise OR, all flag values must be powers of two and the maximum available flag value is 0x80000000.

Future signature flag allocations shall occur via Expert Review as per [RFC8126].

Number	Identifier	Reference
0x01	Reserved	RFC 9987, Section 8.3
0x02	SSH_AGENT_RSA_SHA2_256	RFC 9987, Section 8.3
0x04	SSH_AGENT_RSA_SHA2_512	RFC 9987, Section 8.3

Table 7

9.6. "SSH Agent Extension Request Names" Registry

The "SSH Agent Extension Request Names" registry records the names used in the generic extension request message (SSH_AGENTC_EXTENSION). It is located in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH]. Its initial state consists of the following names.

Future name allocations shall occur via Expert Review as per [RFC8126].

Extension Name	Reference
query	RFC 9987, Section 5.8.1

Table 8

9.7. Additions to the "Extension Names" Registry

IANA has added the following entries to the "Extension Names" registry [IANA-SSH-EXT] in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH].

Extension Name	Reference
agent-forward	RFC 9987, Section 7.1

Table 9

9.8. Additions to the "Connection Protocol Channel Request Names" Registry

IANA has added the following entries to the "Connection Protocol Channel Request Names" registry [IANA-SSH-CHANREQ] in the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH].

Request Type	Reference
agent-req	RFC 9987, Section 7.2

Table 10

9.9. Additions to the "Connection Protocol Channel Types" Registry

IANA has added the following entries to the "Connection Protocol Channel Types" registry [IANA-SSH-CHANATYPE] under the "Secure Shell (SSH) Protocol Parameters" registry group [IANA-SSH].

Channel Type	Reference
agent-connect	RFC 9987, Section 7.3

Table 11

10. Security Considerations

The agent is a service that is tasked with retaining and providing controlled access to what are typically long-lived login authentication credentials. It is, by nature, a sensitive and trusted software component. Moreover, the agent protocol itself does not include any authentication or transport security; ability to communicate with an agent is usually sufficient to invoke it to perform private key operations.

Since being able to access an agent is usually sufficient to perform private key operations, it is critically important that the agent only be exposed to its owner and their authorised delegates. On Unix-like systems, this may be achieved via filesystem permissions on the agent socket and/or identity checks on the client connected to a socket (e.g., SO_PEERCRED on some Unix-like systems). On Windows, access to a named pipe may be controlled by attaching a security descriptor at the time of its creation.

The primary design intention of an agent is that an attacker with unprivileged access to their victim's agent should be prevented from gaining a copy of any keys that have been loaded into it. This may not preclude the attacker from stealing use of those keys (e.g., if they have been loaded without a confirmation constraint).

Given this, the agent should, as far as possible, prevent its memory from being read by other processes to prevent theft of loaded keys. Typically, this includes disabling debugging interfaces and preventing process memory dumps on abnormal termination.

Another, more subtle, means by which keys may be stolen is via cryptographic side-channels. Private key operations may leak information about the contents of keys via differences in timing, power use, or by side effects in the memory subsystems (e.g., CPU caches) of the host running the agent. For the case of a local attacker and an agent holding unconstrained keys, the only limit on the number of private key operations the attacker may be able to observe is the rate at which the CPU can perform signatures. This grants the attacker an almost ideal oracle for side-channel attacks.

While a full treatment of side-channel attacks is beyond the scope of this specification, agents SHOULD use cryptographic implementations that are resistant to side-channel attacks and MAY take additional measures to hide the actual time spent processing private key operations. Failure to do so may expose keys to recovery through these side-channels.

Forwarding access to a local agent over an SSH connection (Section 7) inherently creates a transitive trust relationship. SSH implementations SHOULD NOT forward use of an agent by default, and users SHOULD NOT forward use of an agent to hosts that are not fully trusted, as doing so could expose access to the user's keys to attackers on remote hosts. Agents SHOULD implement additional controls over key visibility and use for forwarded agent connections; otherwise, the user has only an all-or-nothing choice about whether to forward an agent.

Implementation of keys hosted by a token or smartcard requires some care, too. On some systems, tokens may be invoked by providing a path to a shared library that must be loaded to make use of keys hosted on the device (a path to a library for a particular PKCS#11 module, for example). Loading a shared library on most platforms implies automatic execution of code in that library in the address space of the process that loads it. To avoid the loading of potentially hostile code, agents that support loading token-hosted keys via a library path SHOULD ensure that only trusted token provider libraries are loadable. Additionally, agents SHOULD ensure that loaded token library code cannot gain access to other keys loaded in the agent and MAY disallow remote clients from loading token keys entirely. Protection for existing keys from a token library code may be achieved by loading the token library into a separate process to the agent and arranging for the agent to invoke token operations to this process via IPC.

Finally, with respect to the agent locking functionality in Section 5.7, an agent SHOULD take countermeasures against brute-force guessing attacks on the passphrase. This may take the form of enforced delays when an unlock attempt is made with an incorrect password (potentially increasing for subsequent failures), a lockout period where the agent refuses to accept further requests after some threshold of failed unlock attempts has been made, and/or deletion of all keys held by the agent after a threshold of failed unlock attempts.

11. References

11.1. Normative References

[FIPS.186-4]

NIST, "Digital Signature Standard (DSS)", NIST FIPS 186-4, DOI 10.6028/NIST.FIPS.186-4, June 2013, <<https://doi.org/10.6028/NIST.FIPS.186-4>>.

[FIPS.186-5]

NIST, "Digital Signature Standard (DSS)", NIST FIPS 186-5, DOI 10.6028/NIST.FIPS.186-5, February 2023, <<https://doi.org/10.6028/NIST.FIPS.186-5>>.

[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>>.

[RFC4251]

Ylonen, T. and C. Lonvick, Ed., "The Secure Shell (SSH) Protocol Architecture", RFC 4251, DOI 10.17487/RFC4251, January 2006, <<https://www.rfc-editor.org/info/rfc4251>>.

- [RFC4253] Ylonen, T. and C. Lonvick, Ed., "The Secure Shell (SSH) Transport Layer Protocol", RFC 4253, DOI 10.17487/RFC4253, January 2006, <<https://www.rfc-editor.org/info/rfc4253>>.
- [RFC4254] Ylonen, T. and C. Lonvick, Ed., "The Secure Shell (SSH) Connection Protocol", RFC 4254, DOI 10.17487/RFC4254, January 2006, <<https://www.rfc-editor.org/info/rfc4254>>.
- [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>>.
- [RFC8032] Josefsson, S. and I. Liusvaara, "Edwards-Curve Digital Signature Algorithm (EdDSA)", RFC 8032, DOI 10.17487/RFC8032, January 2017, <<https://www.rfc-editor.org/info/rfc8032>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
- [RFC8308] Bider, D., "Extension Negotiation in the Secure Shell (SSH) Protocol", RFC 8308, DOI 10.17487/RFC8308, March 2018, <<https://www.rfc-editor.org/info/rfc8308>>.
- [RFC8332] Bider, D., "Use of RSA Keys with SHA-256 and SHA-512 in the Secure Shell (SSH) Protocol", RFC 8332, DOI 10.17487/RFC8332, March 2018, <<https://www.rfc-editor.org/info/rfc8332>>.
- [RFC8709] Harris, B. and L. Velvindron, "Ed25519 and Ed448 Public Key Algorithms for the Secure Shell (SSH) Protocol", RFC 8709, DOI 10.17487/RFC8709, February 2020, <<https://www.rfc-editor.org/info/rfc8709>>.

11.2. Informative References

- [IANA-PUBKEYS]
 - IANA, "Public Key Algorithm Names", <<https://www.iana.org/assignments/ssh-parameters/>>.
- [IANA-SSH] IANA, "Secure Shell (SSH) Protocol Parameters", <<https://www.iana.org/assignments/ssh-parameters/>>.
- [IANA-SSH-CHANREQ]
 - IANA, "Connection Protocol Channel Types", <<https://www.iana.org/assignments/ssh-parameters/>>.
- [IANA-SSH-CHANTYPE]
 - IANA, "Extension Names", <<https://www.iana.org/assignments/ssh-parameters/>>.
- [IANA-SSH-EXT]
 - IANA, "Connection Protocol Channel Request Names", <<https://www.iana.org/assignments/ssh-parameters/>>.
- [RFC4252] Ylonen, T. and C. Lonvick, Ed., "The Secure Shell (SSH) Authentication Protocol", RFC 4252, DOI 10.17487/RFC4252, January 2006, <<https://www.rfc-editor.org/info/rfc4252>>.
- [RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 8126, DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.

Acknowledgments

This protocol was designed and first implemented by Markus Friedl, based on a similar protocol for an agent to support the legacy SSH version 1 by Tatu Ylonen.

Thanks to Simon Tatham, Niels Mller, James Spencer, Simon Josefsson, Matt Johnston, Jakub Jelen, Rich Salz, Caspar Schutijser, Florian Obser, Martin Thomson, Deb Cooley, and Tero Kivinen who reviewed and helped improve this document.

Author's Address

Damien Miller
OpenSSH
Email: djm@openssh.com
URI: <https://www.openssh.com/>