

Network Working Group  
Ylonen  
Internet-Draft  
Corp  
Expires: December 1, 2004  
Ed.  
Inc  
2004

T.  
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June 2,

**SSH Connection Protocol**  
**draft-ietf-secsh-connect-19.txt**

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Abstract

SSH is a protocol for secure remote login and other secure network services over an insecure network.

This document describes the SSH Connection Protocol. It provides interactive login sessions, remote execution of commands, forwarded TCP/IP connections, and forwarded X11 connections. All of these channels are multiplexed into a single encrypted tunnel.

The SSH Connection Protocol has been designed to run on top of the SSH transport layer and user authentication protocols.

Ylonen & Lonvick  
1]

Expires December 1, 2004

[Page

Table of Contents

<a href="#">1.</a>	Contributors . . . . .	
<a href="#">3</a>		
<a href="#">2.</a>	Introduction . . . . .	
<a href="#">3</a>		
<a href="#">3.</a>	Conventions Used in This Document . . . . .	
<a href="#">3</a>		
<a href="#">4.</a>	Global Requests . . . . .	
<a href="#">3</a>		
<a href="#">5.</a>	Channel Mechanism . . . . .	
<a href="#">4</a>		
<a href="#">5.1</a>	Opening a Channel . . . . .	
<a href="#">4</a>		
<a href="#">5.2</a>	Data Transfer . . . . .	
<a href="#">6</a>		
<a href="#">5.3</a>	Closing a Channel . . . . .	
<a href="#">6</a>		
<a href="#">5.4</a>	Channel-Specific Requests . . . . .	
<a href="#">7</a>		
<a href="#">6.</a>	Interactive Sessions . . . . .	
<a href="#">8</a>		
<a href="#">6.1</a>	Opening a Session . . . . .	
<a href="#">8</a>		
<a href="#">6.2</a>	Requesting a Pseudo-Terminal . . . . .	
<a href="#">8</a>		
<a href="#">6.3</a>	X11 Forwarding . . . . .	
<a href="#">9</a>		
<a href="#">6.3.1</a>	Requesting X11 Forwarding . . . . .	
<a href="#">9</a>		
<a href="#">6.3.2</a>	X11 Channels . . . . .	
<a href="#">10</a>		
<a href="#">6.4</a>	Environment Variable Passing . . . . .	
<a href="#">10</a>		
<a href="#">6.5</a>	Starting a Shell or a Command . . . . .	
<a href="#">10</a>		
<a href="#">6.6</a>	Session Data Transfer . . . . .	
<a href="#">11</a>		
<a href="#">6.7</a>	Window Dimension Change Message . . . . .	
<a href="#">12</a>		
<a href="#">6.8</a>	Local Flow Control . . . . .	
<a href="#">12</a>		
<a href="#">6.9</a>	Signals . . . . .	
<a href="#">12</a>		
<a href="#">6.10</a>	Returning Exit Status . . . . .	
<a href="#">13</a>		
<a href="#">7.</a>	TCP/IP Port Forwarding . . . . .	
<a href="#">14</a>		
<a href="#">7.1</a>	Requesting Port Forwarding . . . . .	
<a href="#">14</a>		
<a href="#">7.2</a>	TCP/IP Forwarding Channels . . . . .	
<a href="#">15</a>		

[8.](#) Encoding of Terminal Modes . . . . .  
[16](#)  
[9.](#) Summary of Message Numbers . . . . .  
[18](#)  
[10.](#) IANA Considerations . . . . .  
[18](#)  
[11.](#) Security Considerations . . . . .  
[18](#)  
[12.](#) References . . . . .  
[19](#)  
[12.1](#) Normative References . . . . .  
[19](#)  
[12.2](#) Informative References . . . . .  
[19](#)  
Authors' Addresses . . . . .  
[20](#)  
Intellectual Property and Copyright Statements . . . . .  
[21](#)

## 1. Contributors

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Additional contributors to this document include [need list]. Listing their names here does not mean that they endorse this document, but that they have contributed to it.

Comments on this internet draft should be sent to the IETF SECSH working group, details at:

<http://ietf.org/html.charters/secsh-charter.html> Note: This

paragraph

will be removed before this document progresses to become an RFC.

## 2. Introduction

The SSH Connection Protocol has been designed to run on top of the SSH transport layer and user authentication protocols. It provides interactive login sessions, remote execution of commands, forwarded TCP/IP connections, and forwarded X11 connections. The service name for this protocol is "ssh-connection".

This document should be read only after reading the SSH architecture document [[SSH-ARCH](#)]. This document freely uses terminology and notation from the architecture document without reference or further explanation.

## 3. Conventions Used in This Document

The keywords "MUST", "MUST NOT", "REQUIRED", "SHOULD", "SHOULD NOT", and "MAY" that appear in this document are to be interpreted as described in [[RFC2119](#)].

The used data types and terminology are specified in the architecture document [[SSH-ARCH](#)].

The architecture document also discusses the algorithm naming conventions that MUST be used with the SSH protocols.

## 4. Global Requests

There are several kinds of requests that affect the state of the remote end "globally", independent of any channels. An example is a request to start TCP/IP forwarding for a specific port. All such requests use the following format.



```
byte      SSH_MSG_GLOBAL_REQUEST
string    request name in US-ASCII only
boolean   want reply
... request-specific data follows
```

Request names follow the DNS extensibility naming convention outlined in [\[SSH-ARCH\]](#).

The recipient will respond to this message with SSH\_MSG\_REQUEST\_SUCCESS or SSH\_MSG\_REQUEST\_FAILURE if 'want reply' is TRUE.

```
byte      SSH_MSG_REQUEST_SUCCESS
.....    response specific data
```

Usually the response specific data is non-existent.

If the recipient does not recognize or support the request, it simply responds with SSH\_MSG\_REQUEST\_FAILURE.

```
byte      SSH_MSG_REQUEST_FAILURE
```

## **5. Channel Mechanism**

All terminal sessions, forwarded connections, etc. are channels. Either side may open a channel. Multiple channels are multiplexed into a single connection.

Channels are identified by numbers at each end. The number referring to a channel may be different on each side. Requests to open a channel contain the sender's channel number. Any other channel-related messages contain the recipient's channel number for the channel.

Channels are flow-controlled. No data may be sent to a channel until a message is received to indicate that window space is available.

### **5.1 Opening a Channel**

When either side wishes to open a new channel, it allocates a local number for the channel. It then sends the following message to the other side, and includes the local channel number and initial window size in the message.

```
byte      SSH_MSG_CHANNEL_OPEN
string    channel type in US-ASCII only
```

uint32 sender channel

Ylonen & Lonvick  
4]

Expires December 1, 2004

[Page



```
uint32    initial window size
uint32    maximum packet size
... channel type specific data follows
```

The channel type is a name as described in the SSH architecture document, with similar extension mechanisms. `sender channel' is a local identifier for the channel used by the sender of this message. `initial window size' specifies how many bytes of channel data can be

sent to the sender of this message without adjusting the window. `Maximum packet size' specifies the maximum size of an individual data packet that can be sent to the sender (for example, one might want to use smaller packets for interactive connections to get better interactive response on slow links).

The remote side then decides whether it can open the channel, and responds with either

```
byte      SSH_MSG_CHANNEL_OPEN_CONFIRMATION
uint32    recipient channel
uint32    sender channel
uint32    initial window size
uint32    maximum packet size
... channel type specific data follows
```

where `recipient channel' is the channel number given in the original open request, and `sender channel' is the channel number allocated by

the other side, or

```
byte      SSH_MSG_CHANNEL_OPEN_FAILURE
uint32    recipient channel
uint32    reason code
string    additional textual information in ISO-10646 UTF-8
encoding  [RFC2279]
string    language tag as defined in [RFC3066]
```

If the recipient of the SSH\_MSG\_CHANNEL\_OPEN message does not support

the specified channel type, it simply responds with SSH\_MSG\_CHANNEL\_OPEN\_FAILURE. The client MAY show the additional information to the user. If this is done, the client software should take the precautions discussed in [[SSH-ARCH](#)].

The following reason codes are defined:

```
#define SSH_OPEN_ADMINISTRATIVELY_PROHIBITED    1
#define SSH_OPEN_CONNECT_FAILED                2
#define SSH_OPEN_UNKNOWN_CHANNEL_TYPE          3
#define SSH_OPEN_RESOURCE_SHORTAGE             4
```

Ylonen & Lonvick  
5]

Expires December 1, 2004

[Page

## **5.2 Data Transfer**

The window size specifies how many bytes the other party can send before it must wait for the window to be adjusted. Both parties use the following message to adjust the window.

```
byte      SSH_MSG_CHANNEL_WINDOW_ADJUST
uint32    recipient channel
uint32    bytes to add
```

After receiving this message, the recipient MAY send the given number of bytes more than it was previously allowed to send; the window size is incremented.

Data transfer is done with messages of the following type.

```
byte      SSH_MSG_CHANNEL_DATA
uint32    recipient channel
string    data
```

The maximum amount of data allowed is the current window size. The window size is decremented by the amount of data sent. Both parties MAY ignore all extra data sent after the allowed window is empty.

Additionally, some channels can transfer several types of data. An example of this is stderr data from interactive sessions. Such data can be passed with SSH\_MSG\_CHANNEL\_EXTENDED\_DATA messages, where a separate integer specifies the type of the data. The available types and their interpretation depend on the type of the channel.

```
byte      SSH_MSG_CHANNEL_EXTENDED_DATA
uint32    recipient_channel
uint32    data_type_code
string    data
```

Data sent with these messages consumes the same window as ordinary data.

Currently, only the following type is defined.

```
#define SSH_EXTENDED_DATA_STDERR      1
```

## **5.3 Closing a Channel**

When a party will no longer send more data to a channel, it SHOULD send SSH\_MSG\_CHANNEL\_EOF.

Ylonen & Lonvick  
6]

Expires December 1, 2004

[Page

```
byte      SSH_MSG_CHANNEL_EOF
uint32    recipient_channel
```

No explicit response is sent to this message; however, the application may send EOF to whatever is at the other end of the channel. Note that the channel remains open after this message, and more data may still be sent in the other direction. This message does not consume window space and can be sent even if no window space is available.

When either party wishes to terminate the channel, it sends SSH\_MSG\_CHANNEL\_CLOSE. Upon receiving this message, a party MUST send back a SSH\_MSG\_CHANNEL\_CLOSE unless it has already sent this message for the channel. The channel is considered closed for a party when it has both sent and received SSH\_MSG\_CHANNEL\_CLOSE, and the party may then reuse the channel number. A party MAY send SSH\_MSG\_CHANNEL\_CLOSE without having sent or received SSH\_MSG\_CHANNEL\_EOF.

```
byte      SSH_MSG_CHANNEL_CLOSE
uint32    recipient_channel
```

This message does not consume window space and can be sent even if no window space is available.

It is recommended that any data sent before this message is delivered to the actual destination, if possible.

#### **5.4 Channel-Specific Requests**

Many channel types have extensions that are specific to that particular channel type. An example is requesting a pty (pseudo terminal) for an interactive session.

All channel-specific requests use the following format.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    request type in US-ASCII characters only
boolean   want reply
... type-specific data
```

If want reply is FALSE, no response will be sent to the request. Otherwise, the recipient responds with either SSH\_MSG\_CHANNEL\_SUCCESS or SSH\_MSG\_CHANNEL\_FAILURE, or request-specific continuation messages. If the request is not recognized or is not supported for the channel, SSH\_MSG\_CHANNEL\_FAILURE is returned.



This message does not consume window space and can be sent even if no window space is available. Request types are local to each channel type.

The client is allowed to send further messages without waiting for the response to the request.

request type names follow the DNS extensibility naming convention outlined in [[SSH-ARCH](#)]

```
byte      SSH_MSG_CHANNEL_SUCCESS
uint32    recipient_channel
```

```
byte      SSH_MSG_CHANNEL_FAILURE
uint32    recipient_channel
```

These messages do not consume window space and can be sent even if no window space is available.

## **6. Interactive Sessions**

A session is a remote execution of a program. The program may be a shell, an application, a system command, or some built-in subsystem. It may or may not have a tty, and may or may not involve X11 forwarding. Multiple sessions can be active simultaneously.

### **6.1 Opening a Session**

A session is started by sending the following message.

```
byte      SSH_MSG_CHANNEL_OPEN
string    "session"
uint32    sender channel
uint32    initial window size
uint32    maximum packet size
```

Client implementations SHOULD reject any session channel open requests to make it more difficult for a corrupt server to attack the client.

### **6.2 Requesting a Pseudo-Terminal**

A pseudo-terminal can be allocated for the session by sending the following message.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient_channel
```





```
string    "pty-req"  
boolean  want_reply  
string    TERM environment variable value (e.g., vt100)  
uint32   terminal width, characters (e.g., 80)  
uint32   terminal height, rows (e.g., 24)  
uint32   terminal width, pixels (e.g., 640)  
uint32   terminal height, pixels (e.g., 480)  
string    encoded terminal modes
```

The encoding of terminal modes is described in Section Encoding of Terminal Modes ([Section 8](#)). Zero dimension parameters MUST be ignored. The character/row dimensions override the pixel dimensions (when nonzero). Pixel dimensions refer to the drawable area of the window.

The dimension parameters are only informational.

The client SHOULD ignore pty requests.

### **6.3 X11 Forwarding**

#### **6.3.1 Requesting X11 Forwarding**

X11 forwarding may be requested for a session by sending

```
byte      SSH_MSG_CHANNEL_REQUEST  
uint32   recipient channel  
string    "x11-req"  
boolean  want_reply  
boolean  single_connection  
string    x11_authentication_protocol  
string    x11_authentication_cookie  
uint32   x11_screen_number
```

It is recommended that the authentication cookie that is sent be a fake, random cookie, and that the cookie is checked and replaced by the real cookie when a connection request is received.

X11 connection forwarding should stop when the session channel is closed; however, already opened forwardings should not be automatically closed when the session channel is closed.

If 'single connection' is TRUE, only a single connection should be forwarded. No more connections will be forwarded after the first,  
or  
after the session channel has been closed.

The "x11 authentication protocol" is the name of the X11 authentication method used, e.g. "MIT-MAGIC-COOKIE-1".



The x11 authentication cookie MUST be hexadecimal encoded.

X Protocol is documented in [[SCHEIFLER](#)].

### **6.3.2 X11 Channels**

X11 channels are opened with a channel open request. The resulting channels are independent of the session, and closing the session channel does not close the forwarded X11 channels.

```
byte      SSH_MSG_CHANNEL_OPEN
string    "x11"
uint32    sender channel
uint32    initial window size
uint32    maximum packet size
string    originator address (e.g. "192.168.7.38")
uint32    originator port
```

The recipient should respond with SSH\_MSG\_CHANNEL\_OPEN\_CONFIRMATION or SSH\_MSG\_CHANNEL\_OPEN\_FAILURE.

Implementations MUST reject any X11 channel open requests if they have not requested X11 forwarding.

### **6.4 Environment Variable Passing**

Environment variables may be passed to the shell/command to be started later. Uncontrolled setting of environment variables in a privileged process can be a security hazard. It is recommended that implementations either maintain a list of allowable variable names

or

only set environment variables after the server process has dropped sufficient privileges.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "env"
boolean   want reply
string    variable name
string    variable value
```

### **6.5 Starting a Shell or a Command**

Once the session has been set up, a program is started at the remote end. The program can be a shell, an application program or a subsystem with a host-independent name. Only one of these requests can succeed per channel.



```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "shell"
boolean   want reply
```

This message will request the user's default shell (typically defined in /etc/passwd in UNIX systems) to be started at the other end.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "exec"
boolean   want reply
string    command
```

This message will request the server to start the execution of the given command. The command string may contain a path. Normal precautions MUST be taken to prevent the execution of unauthorized commands.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "subsystem"
boolean   want reply
string    subsystem name
```

This last form executes a predefined subsystem. It is expected that these will include a general file transfer mechanism, and possibly other features. Implementations may also allow configuring more such

mechanisms. As the user's shell is usually used to execute the subsystem, it is advisable for the subsystem protocol to have a "magic cookie" at the beginning of the protocol transaction to distinguish it from arbitrary output generated by shell initialization scripts etc. This spurious output from the shell may be filtered out either at the server or at the client.

The server SHOULD not halt the execution of the protocol stack when starting a shell or a program. All input and output from these SHOULD be redirected to the channel or to the encrypted tunnel.

It is RECOMMENDED to request and check the reply for these messages. The client SHOULD ignore these messages.

Subsystem names follow the DNS extensibility naming convention outlined in [[SSH-ARCH](#)].

## **6.6 Session Data Transfer**

Data transfer for a session is done using SSH\_MSG\_CHANNEL\_DATA and



SSH\_MSG\_CHANNEL\_EXTENDED\_DATA packets and the window mechanism. The extended data type SSH\_EXTENDED\_DATA\_STDERR has been defined for stderr data.

### **6.7 Window Dimension Change Message**

When the window (terminal) size changes on the client side, it MAY send a message to the other side to inform it of the new dimensions.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient_channel
string    "window-change"
boolean   FALSE
uint32    terminal width, columns
uint32    terminal height, rows
uint32    terminal width, pixels
uint32    terminal height, pixels
```

No response SHOULD be sent to this message.

### **6.8 Local Flow Control**

On many systems, it is possible to determine if a pseudo-terminal is using control-S/control-Q flow control. When flow control is allowed, it is often desirable to do the flow control at the client end to speed up responses to user requests. This is facilitated by the following notification. Initially, the server is responsible for

flow control. (Here, again, client means the side originating the session, and server means the other side.)

The message below is used by the server to inform the client when it can or cannot perform flow control (control-S/control-Q processing). If 'client can do' is TRUE, the client is allowed to do flow control using control-S and control-Q. The client MAY ignore this message.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "xon-xoff"
boolean   FALSE
boolean   client can do
```

No response is sent to this message.

### **6.9 Signals**

A signal can be delivered to the remote process/service using the following message. Some systems may not implement signals, in which case they SHOULD ignore this message.





```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "signal"
boolean   FALSE
string    signal name without the "SIG" prefix.
```

Signal names will be encoded as discussed in the "exit-signal" SSH\_MSG\_CHANNEL\_REQUEST.

### **6.10 Returning Exit Status**

When the command running at the other end terminates, the following message can be sent to return the exit status of the command. Returning the status is RECOMMENDED. No acknowledgment is sent for this message. The channel needs to be closed with SSH\_MSG\_CHANNEL\_CLOSE after this message.

The client MAY ignore these messages.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient_channel
string    "exit-status"
boolean   FALSE
uint32    exit_status
```

The remote command may also terminate violently due to a signal. Such a condition can be indicated by the following message. A zero exit\_status usually means that the command terminated successfully.

```
byte      SSH_MSG_CHANNEL_REQUEST
uint32    recipient channel
string    "exit-signal"
boolean   FALSE
string    signal name without the "SIG" prefix.
boolean   core dumped
string    error message in ISO-10646 UTF-8 encoding
string    language tag as defined in [RFC3066]
```

The signal name is one of the following (these are from [[POSIX](#)])

```
ABRT
ALRM
FPE
HUP
ILL
INT
KILL
PIPE
QUIT
```



SEGV  
TERM  
USR1  
USR2

Additional signal names MAY be sent in the format "sig-name@xyz", where 'sig-name' and 'xyz' may be anything a particular implementor wants (except the '@' sign). However, it is suggested that if a 'configure' script is used, the non-standard signal names it finds be encoded as "SIG@xyz.config.guess", where 'SIG' is the signal name without the "SIG" prefix, and 'xyz' be the host type, as determined by 'config.guess'.

The 'error message' contains an additional explanation of the error message. The message may consist of multiple lines. The client software MAY display this message to the user. If this is done, the client software should take the precautions discussed in [[SSH-ARCH](#)].

## **7. TCP/IP Port Forwarding**

### **7.1 Requesting Port Forwarding**

A party need not explicitly request forwardings from its own end to the other direction. However, if it wishes that connections to a port on the other side be forwarded to the local side, it must explicitly request this.

```
byte      SSH_MSG_GLOBAL_REQUEST
string    "tcpip-forward"
boolean   want reply
string    address to bind (e.g. "0.0.0.0")
uint32    port number to bind
```

'Address to bind' and 'port number to bind' specify the IP address and port to which the socket to be listened is bound. The address should be "0.0.0.0" if connections are allowed from anywhere. (Note that the client can still filter connections based on information passed in the open request.)

Implementations should only allow forwarding privileged ports if the user has been authenticated as a privileged user.

Client implementations SHOULD reject these messages; they are normally only sent by the client.

If a client passes 0 as port number to bind and has want reply TRUE



then the server allocates the next available unprivileged port number

and replies with the following message, otherwise there is no response specific data.

```
byte      SSH_MSG_GLOBAL_REQUEST_SUCCESS
uint32    port that was bound on the server
```

A port forwarding can be canceled with the following message. Note that channel open requests may be received until a reply to this message is received.

```
byte      SSH_MSG_GLOBAL_REQUEST
string    "cancel-tcpip-forward"
boolean   want reply
string    address_to_bind (e.g. "127.0.0.1")
uint32    port number to bind
```

Client implementations SHOULD reject these messages; they are normally only sent by the client.

## 7.2 TCP/IP Forwarding Channels

When a connection comes to a port for which remote forwarding has been requested, a channel is opened to forward the port to the other side.

```
byte      SSH_MSG_CHANNEL_OPEN
string    "forwarded-tcpip"
uint32    sender channel
uint32    initial window size
uint32    maximum packet size
string    address that was connected
uint32    port that was connected
string    originator IP address
uint32    originator port
```

Implementations MUST reject these messages unless they have previously requested a remote TCP/IP port forwarding with the given port number.

When a connection comes to a locally forwarded TCP/IP port, the following packet is sent to the other side. Note that these messages

MAY be sent also for ports for which no forwarding has been explicitly requested. The receiving side must decide whether to allow the forwarding.

```
byte      SSH_MSG_CHANNEL_OPEN
```



```
string    "direct-tcpip"  
uint32    sender channel  
uint32    initial window size  
uint32    maximum packet size  
string    host to connect  
uint32    port to connect  
string    originator IP address  
uint32    originator port
```

`Host to connect' and `port to connect' specify the TCP/IP host and port where the recipient should connect the channel. `Host to connect' may be either a domain name or a numeric IP address.

`Originator IP address' is the numeric IP address of the machine where the connection request comes from, and `originator port' is the port on the originator host from where the connection came from.

Forwarded TCP/IP channels are independent of any sessions, and closing a session channel does not in any way imply that forwarded connections should be closed.

Client implementations SHOULD reject direct TCP/IP open requests for security reasons.

## **8. Encoding of Terminal Modes**

Terminal modes (as passed in a pty request) are encoded into a byte stream. It is intended that the coding be portable across different environments.

The tty mode description is a stream of bytes. The stream consists of opcode-argument pairs. It is terminated by opcode TTY\_OP\_END (0).

Opcodes 1 to 159 have a single uint32 argument. Opcodes 160 to 255 are not yet defined, and cause parsing to stop (they should only be used after any other data).

The client SHOULD put in the stream any modes it knows about, and the server MAY ignore any modes it does not know about. This allows some

degree of machine-independence, at least between systems that use a POSIX-like tty interface. The protocol can support other systems as well, but the client may need to fill reasonable values for a number of parameters so the server pty gets set to a reasonable mode (the server leaves all unspecified mode bits in their default values, and only some combinations make sense).

The following opcodes have been defined. The naming of opcodes mostly follows the POSIX terminal mode flags.

Ylonen & Lonvick  
16]

Expires December 1, 2004

[Page



0	TTY_OP_END	Indicates end of options.
1	VINTR	Interrupt character; 255 if none. Similarly for the other characters. Not all of these characters are supported on all systems.
2	VQUIT	The quit character (sends SIGQUIT signal on POSIX systems).
3	VERASE	Erase the character to left of the cursor.
4	VKILL	Kill the current input line.
5	VEOF	End-of-file character (sends EOF from the terminal).
6	VEOL	End-of-line character in addition to carriage return and/or linefeed.
7	VEOL2	Additional end-of-line character.
8	VSTART	Continues paused output (normally control-Q).
9	VSTOP	Pauses output (normally control-S).
10	VSUSP	Suspends the current program.
11	VDSUSP	Another suspend character.
12	VREPRINT	Reprints the current input line.
13	VWERASE	Erases a word left of cursor.
14	VLNEXT	Enter the next character typed literally, even if it is a special character
15	VFLUSH	Character to flush output.
16	VSWTCH	Switch to a different shell layer.
17	VSTATUS	Prints system status line (load, command, pid etc).
18	VDISCARD	Toggles the flushing of terminal output.
30	IGNPAR	The ignore parity flag. The parameter SHOULD be 0 if this flag is FALSE set, and 1 if it is TRUE.
31	PARMRK	Mark parity and framing errors.
32	INPCK	Enable checking of parity errors.
33	ISTRIP	Strip 8th bit off characters.
34	INLCR	Map NL into CR on input.
35	IGNCR	Ignore CR on input.
36	ICRNL	Map CR to NL on input.
37	IUCLC	Translate uppercase characters to lowercase.
38	IXON	Enable output flow control.
39	IXANY	Any char will restart after stop.
40	IXOFF	Enable input flow control.
41	IMAXBEL	Ring bell on input queue full.
50	ISIG	Enable signals INTR, QUIT, [D]SUSP.
51	ICANON	Canonicalize input lines.
52	XCASE	Enable input and output of uppercase characters by preceding their lowercase equivalents with `\'.
53	ECHO	Enable echoing.
54	ECHOE	Visually erase chars.
55	ECHOK	Kill character discards current line.
56	ECHONL	Echo NL even if ECHO is off.

57 NOFLSH Don't flush after interrupt.  
58 TOSTOP Stop background jobs from output.  
59 IEXTEN Enable extensions.

Ylonen & Lonvick  
17]

Expires December 1, 2004

[Page

60	ECHOCTL	Echo control characters as ^(\Char).
61	ECHOKE	Visual erase for line kill.
62	PENDIN	Retype pending input.
70	OPOST	Enable output processing.
71	OLCUC	Convert lowercase to uppercase.
72	ONLCR	Map NL to CR-NL.
73	OCRNL	Translate carriage return to newline (output).
74	ONOCR	Translate newline to carriage return-newline (output).
75	ONLRET	Newline performs a carriage return (output).
90	CS7	7 bit mode.
91	CS8	8 bit mode.
92	PARENB	Parity enable.
93	PARODD	Odd parity, else even.

128 TTY\_OP\_ISPEED Specifies the input baud rate in bits per second.

129 TTY\_OP\_OSPEED Specifies the output baud rate in bits per second.

## **9. Summary of Message Numbers**

#define	SSH_MSG_GLOBAL_REQUEST	80
#define	SSH_MSG_REQUEST_SUCCESS	81
#define	SSH_MSG_REQUEST_FAILURE	82
#define	SSH_MSG_CHANNEL_OPEN	90
#define	SSH_MSG_CHANNEL_OPEN_CONFIRMATION	91
#define	SSH_MSG_CHANNEL_OPEN_FAILURE	92
#define	SSH_MSG_CHANNEL_WINDOW_ADJUST	93
#define	SSH_MSG_CHANNEL_DATA	94
#define	SSH_MSG_CHANNEL_EXTENDED_DATA	95
#define	SSH_MSG_CHANNEL_EOF	96
#define	SSH_MSG_CHANNEL_CLOSE	97
#define	SSH_MSG_CHANNEL_REQUEST	98
#define	SSH_MSG_CHANNEL_SUCCESS	99
#define	SSH_MSG_CHANNEL_FAILURE	100

## **10. IANA Considerations**

This document is part of a set. The IANA considerations for the SSH protocol as defined in [\[SSH-ARCH\]](#), [\[SSH-TRANS\]](#), [\[SSH-USERAUTH\]](#), and this document, are detailed in [\[SSH-NUMBERS\]](#).

## **11. Security Considerations**

This protocol is assumed to run on top of a secure, authenticated transport. User authentication and protection against network-level attacks are assumed to be provided by the underlying protocols.



Full security considerations for this protocol are provided in [SSH-ARCH]. Specific to this document, it is RECOMMENDED that implementations disable all the potentially dangerous features (e.g. agent forwarding, X11 forwarding, and TCP/IP forwarding) if the host key has changed without notice or explanation.

## **12. References**

### **12.1 Normative References**

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Funding for the RFC Editor function is currently provided by the Internet Society.

