Chapter 9. OpenSSH

SSH (Secure Shell) is a protocol which facilitates secure communications between two systems using a client-server architecture and allows users to log in to server host systems remotely. Unlike other remote communication protocols, such as **FTP** or **Telnet**, SSH encrypts the login session, rendering the connection difficult for intruders to collect unencrypted passwords.

The **ssh** program is designed to replace older, less secure terminal applications used to log in to remote hosts, such as **telnet** or **rsh**. A related program called **scp** replaces older programs designed to copy files between hosts, such as **rcp**. Because these older applications do not encrypt passwords transmitted between the client and the server, avoid them whenever possible. Using secure methods to log in to remote systems decreases the risks for both the client system and the remote host.

Red Hat Enterprise Linux includes the general OpenSSH package, *openssh*, as well as the OpenSSH server, *openssh-server*, and client, *openssh-clients*, packages. Note, the OpenSSH packages require the OpenSSL package *openssl-libs*, which installs several important cryptographic libraries, enabling OpenSSH to provide encrypted communications.

9.1. The SSH Protocol

9.1.1. Why Use SSH?

Potential intruders have a variety of tools at their disposal enabling them to disrupt, intercept, and re- route network traffic in an effort to gain access to a system. In general terms, these threats can be categorized as follows:

Interception of communication between two systems

The attacker can be somewhere on the network between the communicating parties, copying any information passed between them. He may intercept and keep the information, or alter the information and send it on to the intended recipient.

This attack is usually performed using a *packet sniffer*, a rather common network utility that captures each packet flowing through the network, and analyzes its content.

Impersonation of a particular host

Attacker's system is configured to pose as the intended recipient of a transmission. If this strategy works, the user's system remains unaware that it is communicating with the wrong host.

This attack can be performed using a technique known as *DNS poisoning*, or via so-called *IP spoofing*. In the first case, the intruder uses a cracked DNS server to point client systems to a maliciously duplicated host. In the second case, the intruder sends falsified network packets that appear to be from a trusted host.

Both techniques intercept potentially sensitive information and, if the interception is made for hostile reasons, the results can be disastrous. If SSH is used for remote shell login and file copying, these security threats can be greatly diminished. This is because the SSH client and server use digital signatures to verify their identity. Additionally, all communication between the client and server systems is encrypted. Attempts to spoof the identity of either side of a communication does not work, since each packet is encrypted using a key known only by the local and remote systems.

9.1.2. Main Features

The SSH protocol provides the following safeguards:

No one can pose as the intended server

After an initial connection, the client can verify that it is connecting to the same server it had connected to previously.

No one can capture the authentication information

The client transmits its authentication information to the server using strong, 128-bit encryption.

No one can intercept the communication

All data sent and received during a session is transferred using 128-bit encryption, making intercepted transmissions extremely difficult to decrypt and read.

Additionally, it also offers the following options:

It provides secure means to use graphical applications over a network

Using a technique called *X11 forwarding*, the client can forward *X11* (*X Window System*) applications from the server.

It provides a way to secure otherwise insecure protocols

The SSH protocol encrypts everything it sends and receives. Using a technique called *port forwarding*, an SSH server can become a conduit to securing otherwise insecure protocols, like POP, and increasing overall system and data security.

It can be used to create a secure channel

The OpenSSH server and client can be configured to create a tunnel similar to a virtual private network for traffic between server and client machines.

It supports the Kerberos authentication

OpenSSH servers and clients can be configured to authenticate using the GSSAPI (Generic Security Services Application Program Interface) implementation of the Kerberos network authentication protocol.

9.1.3. Prot ocol Versions

Two varieties of SSH currently exist: version 1, and newer version 2. The OpenSSH suite under Red Hat Enterprise Linux uses SSH version 2, which has an enhanced key exchange algorithm not vulnerable to the known exploit in version 1. However, for compatibility reasons, the OpenSSH suite does support version 1 connections as well.

Important

To ensure maximum security for your connection, it is recommended that only SSH version 2-compatible servers and clients are used whenever possible.

9.1.4 . Event Sequence of an SSH Connect ion

The following series of events help protect the integrity of SSH communication between two hosts.

1. A cryptographic handshake is made so that the client can verify that it is communicating with the correct server.
2. The transport layer of the connection between the client and remote host is encrypted using a symmetric cipher.
3. The client authenticates itself to the server.
4. The client interacts with the remote host over the encrypted connection.

9.1.4.1. .1 . T ranspo rt Layer

The primary role of the transport layer is to facilitate safe and secure communication between the two hosts at the time of authentication and during subsequent communication. The transport layer accomplishes this by handling the encryption and decryption of data, and by providing integrity protection of data packets as they are sent and received. The transport layer also provides compression, speeding the transfer of information.

Once an SSH client contacts a server, key information is exchanged so that the two systems can correctly construct the transport layer. The following steps occur during this exchange:

- Keys are exchanged
- The public key encryption algorithm is determined
- The symmetric encryption algorithm is determined
- The message authentication algorithm is determined
- The hash algorithm is determined

During the key exchange, the server identifies itself to the client with a unique *host key*. If the client has never communicated with this particular server before, the server's host key is unknown to the client and it does not connect. OpenSSH gets around this problem by accepting the server's host key. This is done after the user is notified and has both accepted and verified the new host key. In subsequent connections, the server's host key is checked against the saved version on the client, providing confidence that the client is indeed communicating with the intended server. If, in the future, the host key no longer matches, the user must remove the client's saved version before a connection can occur.

Warning

It is possible for an attacker to masquerade as an SSH server during the initial contact since the local system does not know the difference between the intended server and a false one set up by an attacker. To help prevent this, verify the integrity of a new SSH server by contacting the server administrator before connecting for the first time or in the event of a host key mismatch.

SSH is designed to work with almost any kind of public key algorithm or encoding format. After an initial key exchange creates a hash value used for exchanges and a shared secret value, the two systems immediately begin calculating new keys and algorithms to protect authentication and future data sent over the connection.

After a certain amount of data has been transmitted using a given key and algorithm (the exact amount depends on the SSH implementation), another key exchange occurs, generating another set of hash values and a new shared secret value. Even if an attacker is able to determine the hash and shared secret value, this information is only useful for a limited period of time.

9.1.4.2. .2 . Aut hent icat io n

Once the transport layer has constructed a secure tunnel to pass information between the two systems, the server tells the client the different authentication methods supported, such as using a private key-encoded signature or typing a password. The client then tries to authenticate itself to the server using one of these supported methods.

SSH servers and clients can be configured to allow different types of authentication, which gives each side the optimal amount of control. The server can decide which encryption methods it supports based on its security model, and the client can choose the order of authentication methods to attempt from the available options.

9.1.4.3. .3. Channels

After a successful authentication over the SSH transport layer, multiple channels are opened via a technique called *multiplexing* [1] . Each of these channels handles communication for different terminal sessions and for forwarded X11 sessions.

Both clients and servers can create a new channel. Each channel is then assigned a different number on each end of the connection. When the client attempts to open a new channel, the clients sends the channel number along with the request. This information is stored by the server and is used to direct communication to that channel. This is done so that different types of sessions do not affect one another and so that when a given session ends, its channel can be closed without disrupting the primary SSH connection.

Channels also support *flow-control*, which allows them to send and receive data in an orderly fashion. In this way, data is not sent over the channel until the client receives a message that the channel is open.

The client and server negotiate the characteristics of each channel automatically, depending on the type of service the client requests and the way the user is connected to the network. This allows great flexibility in handling different types of remote connections without having to change the basic infrastructure of the protocol.

9.2. Configuring OpenSSH

9.2.1. Configurat ion Files

There are two different sets of configuration files: those for client programs (that is, **ssh**, **scp**, and **sftp**), and those for the server (the **sshd** daemon).

System-wide SSH configuration information is stored in the **/etc/ssh/** directory as described in Table 9.1, “ System-wide configuration files” . User-specific SSH configuration information is stored in **~/.ssh/** within the user's home directory as described in Table 9.2, “ User-specific configuration files” .

Table 9 . 1. System- wide configuration f iles

File	Description

File	Description
/etc/ssh/moduli	Contains Diffie-Hellman groups used for the Diffie-Hellman key exchange which is critical for constructing a secure transport layer. When keys are exchanged at the beginning of an SSH session, a shared, secret value is created which cannot be determined by either party alone. This value is then used to provide host authentication.
/etc/ssh/ssh_config	The default SSH client configuration file. Note that it is overridden by **~/.ssh/config** if it exists.
/etc/ssh/sshd_config	The configuration file for the **sshd** daemon.
/etc/ssh/ssh_host_ecdsa_key	The ECDSA private key used by the **sshd** daemon.
/etc/ssh/ssh_host_ecdsa_key.pub	The ECDSA public key used by the **sshd** daemon.
/etc/ssh/ssh_host_key	The RSA private key used by the **sshd** daemon for version 1 of the SSH protocol.
/etc/ssh/ssh_host_key.pub	The RSA public key used by the **sshd** daemon for version 1 of the SSH protocol.
/etc/ssh/ssh_host_rsa_key	The RSA private key used by the **sshd** daemon for version 2 of the SSH protocol.
/etc/ssh/ssh_host_rsa_key.pub	The RSA public key used by the **sshd** daemon for version 2 of the SSH protocol.
/etc/pam.d/sshd	The PAM configuration file for the **sshd** daemon.
/etc/sysconfig/sshd	Configuration file for the **sshd** service.

Table 9.2. User-specific configuration files

File	Description
~/.ssh/authorized_keys	Holds a list of authorized public keys for servers. When the client connects to a server, the server authenticates the client by checking its signed public key stored within this file.
~/.ssh/id_ecdsa	Contains the ECDSA private key of the user.
~/.ssh/id_ecdsa.pub	The ECDSA public key of the user.
~/.ssh/id_rsa	The RSA private key used by **ssh** for version 2 of the SSH protocol.
~/.ssh/id_rsa.pub	The RSA public key used by **ssh** for version 2 of the SSH protocol.
~/.ssh/identity	The RSA private key used by **ssh** for version 1 of the SSH protocol.
~/.ssh/identity.pub	The RSA public key used by **ssh** for version 1 of the SSH protocol.
~/.ssh/known_hosts	Contains host keys of SSH servers accessed by the user. This file is very important for ensuring that the SSH client is connecting to the correct SSH server.

For information concerning various directives that can be used in the SSH configuration files, see the **ssh_config** (5) and **sshd_config** (5) manual pages.

9.2.2. Starting an OpenSSH Server

In order to run an OpenSSH server, you must have the *openssh-server* package installed (see Section 7.2.4, “Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux 7).

To start the **sshd** daemon in the current session, type the following at a shell prompt as **root**:

```
~]# systemctl start sshd.service
```

To stop the running **sshd** daemon in the current session, use the following command as **root**:

```
~]# systemctl stop sshd.service
```

If you want the daemon to start automatically at the boot time, type as **root**:

```
~]# systemctl enable sshd.service
ln -s '/usr/lib/systemd/system/sshd.service' '/etc/systemd/system/multi-user.target.wants/sshd.service'
```

For more information on how to manage system services in Red Hat Enterprise Linux, see Chapter 8, *Managing Services with systemd*.

Note that if you reinstall the system, a new set of identification keys will be created. As a result, clients who had connected to the system with any of the OpenSSH tools before the reinstall will see the following message:

```
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Someone could be eavesdropping on you right now (man-in-the-middle attack)!
It is also possible that the RSA host key has just been changed.
```

To prevent this, you can backup the relevant files from the **/etc/ssh/** directory (see Table 9.1, "System-wide configuration files" for a complete list), and restore them whenever you reinstall the system.

9.2.3. Requiring SSH for Remote Connections

For SSH to be truly effective, using insecure connection protocols should be prohibited. Otherwise, a user's password may be protected using SSH for one session, only to be captured later while logging in using Telnet. Some services to disable include **telnet**, **rsh**, **rlogin**, and **vsftpd**.

For information on how to configure the **vsftpd** service, see Section 14.2, "FTP". To learn how to manage system services in Red Hat Enterprise Linux 7, read Chapter 8, *Managing Services with systemd*.

9.2.4. Using Key-based Authentication

To improve the system security even further, generate SSH key pairs and then enforce key-based authentication by disabling password authentication. To do so, open the **/etc/ssh/sshd_config** configuration file in a text editor such as **vi** or **nano**, and change the **PasswordAuthentication** option as follows:

```
PasswordAuthentication no
```

9.3. OpenSSH Client s

To connect to an OpenSSH server from a client machine, you must have the *openssh-clients* package installed (see Section 7.2.4, “ Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux).

9.3.1. Using t he ssh Ut ilit y

The **ssh** utility allows you to log in to a remote machine and execute commands there. It is a secure replacement for the **rlogin**, **rsh**, and **telnet** programs.

Similarly to the **telnet** command, log in to a remote machine by using the following command:

```
ssh hostname
```

For example, to log in to a remote machine named **penguin.example.com**, type the following at a shell prompt:

```
~]$ ssh penguin.example.com
```

This will log you in with the same user name you are using on the local machine. If you want to specify a different user name, use a command in the following form:

```
ssh username@hostname
```

For example, to log in to **penguin.example.com** as **USER**, type:

```
~]$ ssh USER@penguin.example.com
```

The first time you initiate a connection, you will be presented with a message similar to this:

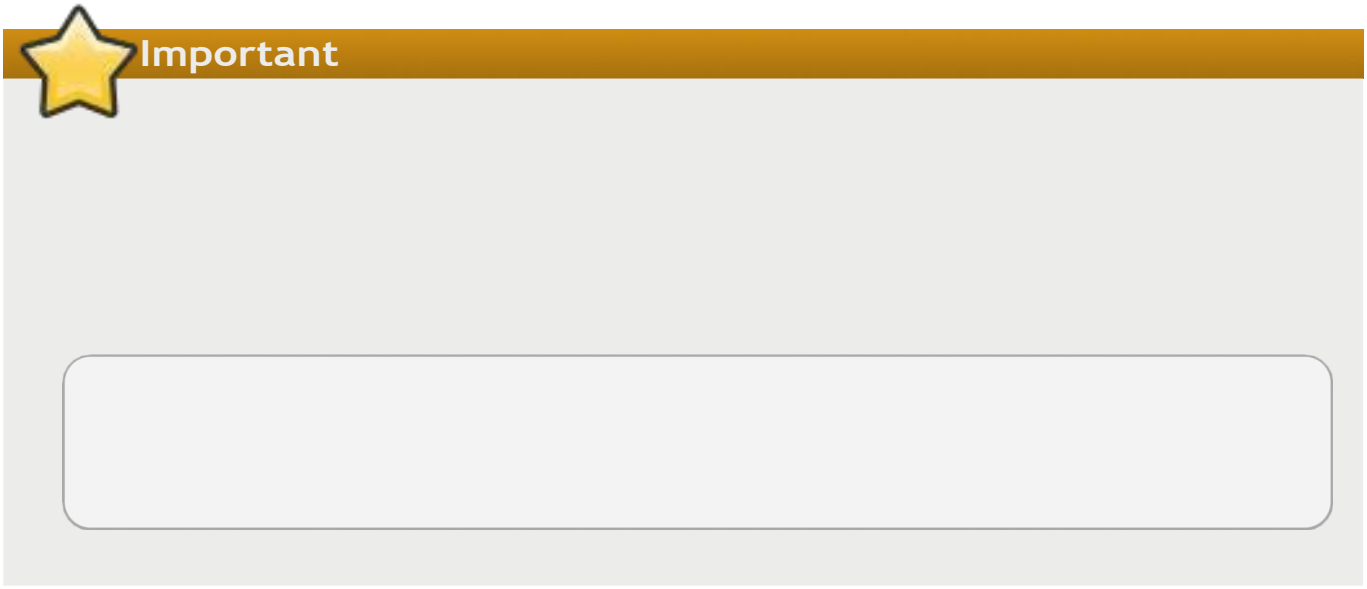
```
The authenticity of host 'penguin.example.com' can't be established. ECDSA key fingerprint is 256
Are you sure you want to continue connecting (yes/no)?
```

Users should always check if the fingerprint is correct before answering the question in this dialog. The user can ask the administrator of the server to confirm the key is correct. This should be done in a secure and previously agreed way. If the user has access to the server's host keys, the fingerprint can be checked by using the **ssh-keygen** command as follows:

```
~]# ssh-keygen -l -f /etc/ssh/ssh_host_ecdsa_key.pub
256 da:24:43:0b:2e:c1:3f:a1:84:13:92:01:52:b4:84:ff(ECDSA)
```

Type **yes** to accept the key and confirm the connection. You will see a notice that the server has been added to the list of known hosts, and a prompt asking for your password:

```
Warning: Permanently added 'penguin.example.com' (ECDSA) to the list of known hosts.
USER@penguin.example.com's password:
```



After entering the password, you will be provided with a shell prompt for the remote machine.

Alternatively, the **ssh** program can be used to execute a command on the remote machine without logging in to a shell prompt:

```
ssh [username@ ]hostname command
```

For example, the **/etc/red hat-rel ease** file provides information about the Red Hat Enterprise Linux version. To view the contents of this file on **peng ui n. exampl e. co m**, type:

```
~]$ ssh USER @ peng uin. example. co m cat /etc/red hat-release
USER@ penguin.example.com's password:
Red Hat Enterprise Linux Server release 7.0 (Maipo)
```

After you enter the correct password, the user name will be displayed, and you will return to your local shell prompt.

9.3.2. Using t he scp Ut ilit y

scp can be used to transfer files between machines over a secure, encrypted connection. In its design, it is very similar to **rcp**.

To transfer a local file to a remote system, use a command in the following form:

```
scp localfile username@ hostname: remotefile
```

For example, if you want to transfer **tag l ist. vi m** to a remote machine named **peng ui n. exampl e. co m**, type the following at a shell prompt:

```
~]$ scp tag list. vim USER @ peng uin. example. co m:. vim/plug in/tag list. vim
USER@ penguin.example.com's password:
taglist.vim 100% 144KB 144.5KB/s
00:00
```

Multiple files can be specified at once. To transfer the contents of **. vi m/pl ug i n/** to the same directory on the remote machine **peng ui n. exampl e. co m**, type the following command:

```
~]$ scp .vim/plugin/* USER@penguin.example.com:.vim/plugin/
USER@penguin.example.com's password:
closetag.vim                                  100%   13KB  12.6KB/s
00:00
snippetsEmu.vim                               100%   33KB  33.1KB/s
00:00
taglist.vim                                   100%  144KB 144.5KB/s
00:00
```

To transfer a remote file to the local system, use the following syntax:

```
scp username@hostname:remotefile localfile
```

For instance, to download the **.vimrc** configuration file from the remote machine, type:

```
~]$ scp USER@penguin.example.com:.vimrc .vimrc
USER@penguin.example.com's password:
.vimrc                                        100% 2233     2.2KB/s
00:00
```

9.3.3. Using the sftp Utility

The **sftp** utility can be used to open a secure, interactive FTP session. In its design, it is similar to **ftp** except that it uses a secure, encrypted connection.

To connect to a remote system, use a command in the following form:

```
sftp username@hostname
```

For example, to log in to a remote machine named **penguin.example.com** with **USER** as a user name, type:

```
~]$ sftp USER@penguin.example.com
USER@penguin.example.com's password:
Connected to
```

After you enter the correct password, you will be presented with a prompt. The **sftp** utility accepts a set of commands similar to those used by **ftp** (see Table 9.3, “A selection of available sftp commands”).

Table 9.3. A selection of available sftp commands

Command	Description
ls [*directory*]	List the content of a remote *directory*. If none is supplied, a current working directory is used by default.
cd *directory*	Change the remote working directory to *directory*.
mkdir *directory*	Create a remote *directory*.
rmdir *path*	Remove a remote *directory*.
put *localfile* [*remotefile*]	Transfer *localfile* to a remote machine.
get *remotefile* [*localfile*]	Transfer *remotefile* from a remote machine.

For a complete list of available commands, see the **sftp**(1) manual page.

9.4. . More Than a Secure Shell

A secure command-line interface is just the beginning of the many ways SSH can be used. Given the proper amount of bandwidth, X11 sessions can be directed over an SSH channel. Or, by using TCP/IP forwarding, previously insecure port connections between systems can be mapped to specific SSH channels.

9.4 .1. X11 Forwarding

To open an X11 session over an SSH connection, use a command in the following form:

```
ssh -Y username@ hostname
```

For example, to log in to a remote machine named **peng uin. exampl e. co m** with **USER** as a user name, type:

```
~]$ ssh -Y USER @ peng uin. example. co m
USER@ penguin.example.com's password:
```

When an X program is run from the secure shell prompt, the SSH client and server create a new secure channel, and the X program data is sent over that channel to the client machine transparently.

Note that the X Window system must be installed on the remote system before X11 forwarding can take place. Enter the following command as **ro o t** to install the X11 package group:

```
~]# yum g ro up install "X Wind o w System"
```

For more information on package groups, see Section 7.3, “ Working with Package Groups”.

X11 forwarding can be very useful. For example, X11 forwarding can be used to create a secure, interactive session of the **Print Settings** utility. To do this, connect to the server using **ssh** and type:

```
~]$ system-co nfig -printer &
```

The **Print Settings** tool will appear, allowing the remote user to safely configure printing on the remote system.

9.4 .2. Port Forwarding

SSH can secure otherwise insecure **T C P / I P** protocols via port forwarding. When using this technique, the SSH server becomes an encrypted conduit to the SSH client.

Port forwarding works by mapping a local port on the client to a remote port on the server. SSH can map any port from the server to any port on the client. Port numbers do not need to match for this technique to work.

Note

Setting up port forwarding to listen on ports below 1024 requires **root** level access.

To create a TCP/IP port forwarding channel which listens for connections on the **localhost**, use a command in the following form:

```
ssh -L local-port: remote-hostname: remote-port username@ hostname
```

For example, to check email on a server called **mail.example.com** using **POP3** through an encrypted connection, use the following command:

```
~]$ ssh -L 1100:mail.example.com:110 mail.example.com
```

Once the port forwarding channel is in place between the client machine and the mail server, direct a POP3 mail client to use port **1100** on the **localhost** to check for new email. Any requests sent to port **1100** on the client system will be directed securely to the **mail.example.com** server.

If **mail.example.com** is not running an SSH server, but another machine on the same network is, SSH can still be used to secure part of the connection. However, a slightly different command is necessary:

```
~]$ ssh -L 1100:mail.example.com:110 other.example.com
```

In this example, POP3 requests from port **1100** on the client machine are forwarded through the SSH connection on port **22** to the SSH server, **other.example.com**. Then, **other.example.com** connects to port **110** on **mail.example.com** to check for new email. Note that when using this technique, only the connection between the client system and **other.example.com** SSH server is secure.

Port forwarding can also be used to get information securely through network firewalls. If the firewall is configured to allow SSH traffic via its standard port (that is, port 22) but blocks access to other ports, a connection between two hosts using the blocked ports is still possible by redirecting their communication over an established SSH connection.

Important

Using port forwarding to forward connections in this manner allows any user on the client system to connect to that service. If the client system becomes compromised, the attacker also has access to forwarded services.

System administrators concerned about port forwarding can disable this functionality on the server by specifying a **No** parameter for the **AllowTcpForwarding** line in **/etc/ssh/sshd_config** and restarting the **sshd** service.

Assignments

1 Mark Questions

1) SSH stands for_____
2) Where do you locate SSH configuration files?
3) Name the SSH Server Package
4) Name the SSH Client Package
5) What is IP Spoofing?
6) What is DNS Poisoning?
7) How to login to ssh server using ssh client?

7 Mark questions

1) What is SSH? What are the main features of SSH?
2) What are the two major types of attacks on Network System? Explain
3) What are the steps involved in establishing a SSH communication between two hosts?
4) Give the procedure to start SSH service at a server and to log in to it from a remote PC.
5) What is scp? Give the procedure to copy a local file to a remote file and also remote file to a local file using scp.
6) What is sftp? List the different commands available with sftp.
7) Give the different packages and their significance available with openssh Package.