June 26, 2007

SSH
The Secure Shell

UniForum

Chicago

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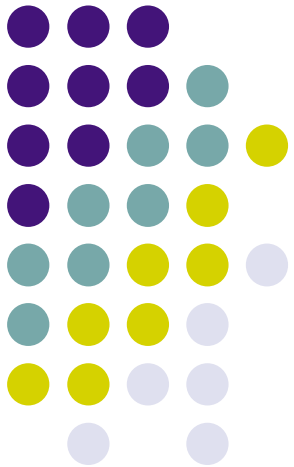
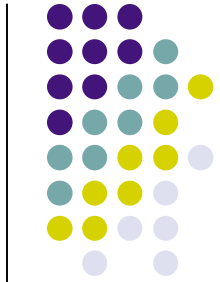


Platform: Linux and Unix



What is SSH?

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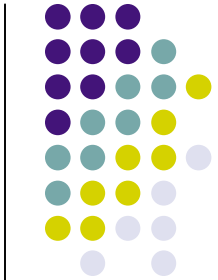
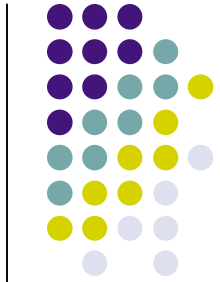
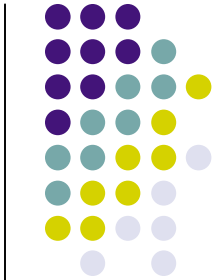


- The Secure Shell
- It is a protocol not a product
- Software based approach to network security
- Encrypts the data sent between the computers
- Client/Server architecture
- Comes with all Linux distribution, Mac OS X, AIX, Sun Solaris, OpenBSD and other Unix variants
- Ported to other operating systems, such as Windows, Palm OS, Amiga, etc.
- Other clients, such as, scp, sftp, etc. are also available
- Replacement for telnet, rlogin, rsh, rcp, ftp, etc.

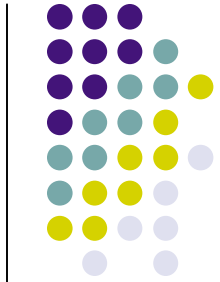


What is SSH Not

What SSH is NOT

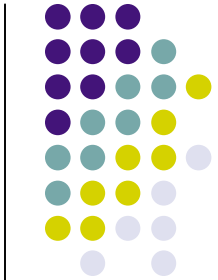


- It is not a true shell like csh, ksh, sh, etc.
- It is not a command interpreter
- It creates secure channel for running commands on remote computer
- It is not a complete security solution
- It will not protect against trojans, viruses, etc.

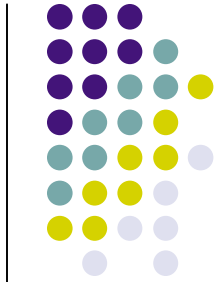


History

History



- In 1995, Tatu Ylönen, a researcher at Helsinki University designed the first version of the protocol (now called SSH-1)
- In July of 1995, he released SSH1 as free software
- In December of 1995 he formed SSH Communication Security to market and develop SSH
- In 1996 SSH-2 was developed, it was incompatible with SSH-1
- SCS released SSH-2 in 1998 and had more restrictive license
- IETF formed group called SECSH to standardize the protocol
- OpenSSH, free implementation of SSH-2 protocol was released from OpenBSD project.
- In 2006 IETF SECSH group released SSH-2 as internet standard (RFC 4251)



Terminology

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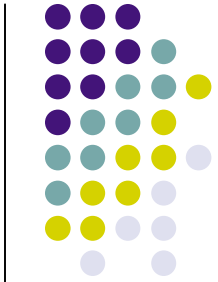
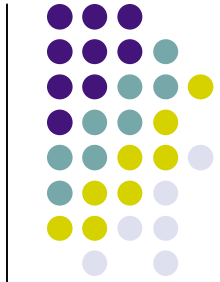
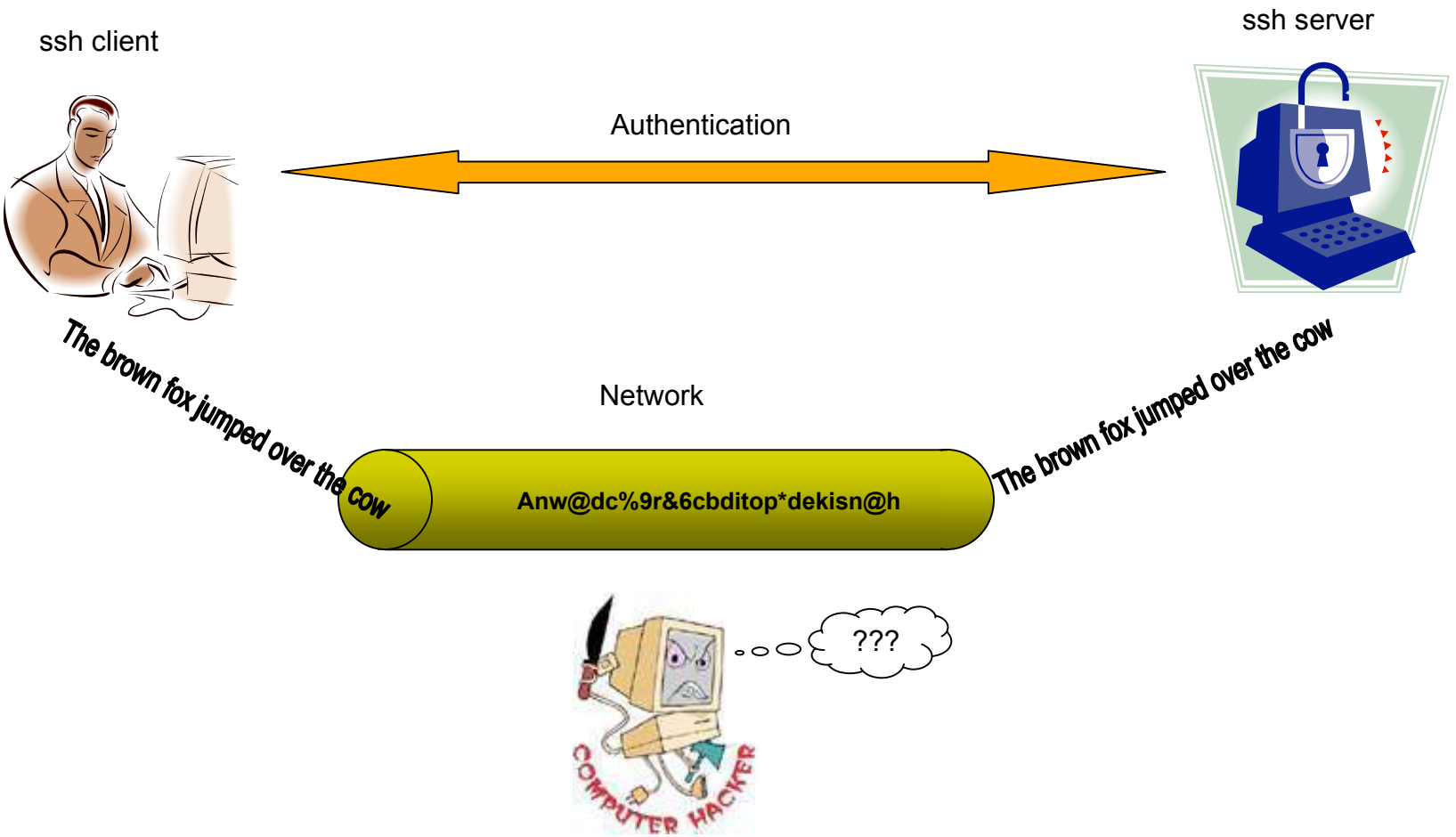


SSH - Generic term used for SSH protocols
ssh - Client command for running remote command
sshd - Server program
SSH-1 - Version 1 of the protocol
SSH-2 - Version 2 of the protocol
OpenSSH - Product from open BSD project

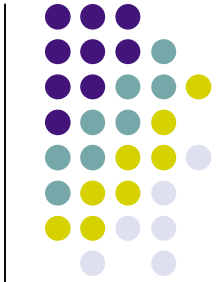


SSH Architecture

SSH Architecture

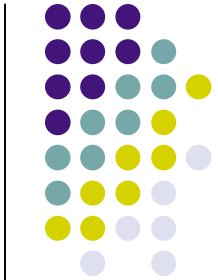


SSH Layers



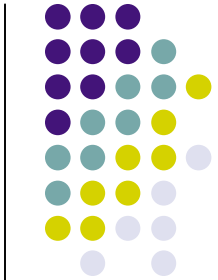
Application Layer	**ssh-connection** Session multiplexing, X11 and port forwarding, remote command execution, SOCKS proxy, etc.
	ssh-userauth User authentication using public key, password, host based, etc.
	ssh-transport Initial key exchange and server authentication, setup encryption
Transport Layer	**TCP**
Internet Layer	**IP**
Network Access Layer	**Ethernet**

SSH Connection Sequence



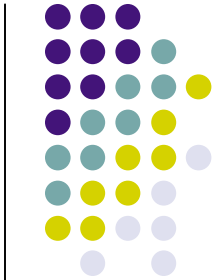
- A cryptographic handshake is made with the server
- The connection between client and remote server is encrypted using symmetric cipher
- Client authenticates itself
- Client can now interact safely with remote server over encrypted connection

SSH Features



- Strong encryption
- Strong authentication
- Authorization
- Integrity of communication
- Forwarding or tunneling

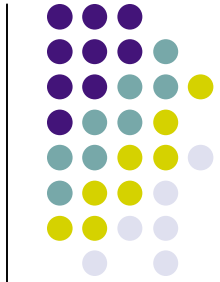
SSH will protect against



- Eavesdropping of data transmitted over the network
- Manipulation of data at intermediate elements in the network (e.g. routers)
- IP address spoofing where an attack hosts pretends to be a trusted host by sending packets with the source address of the trusted host
- DNS spoofing of trusted host names/IP addresses
- IP source routing

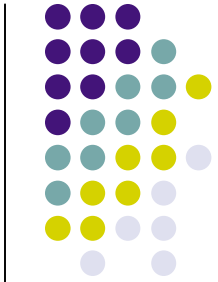
SSH will not protect against

- Incorrect configuration or usage
- A compromised root account
  - If you login from a host to a server and an attacker has control of root on either side, he/she can listen to your session by reading from the pseudo-terminal device, even though SSH is encrypted on the network, SSH must communicate in clear text with the terminal device
- Insecure home directories: if an attacker can modify files in your home directory (e.g. via NFS) he may be able to fool SSH



Installing SSH

Downloading Source Code

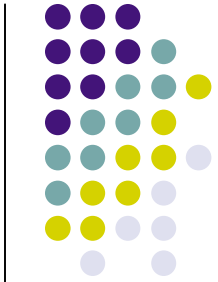


You may download the source from

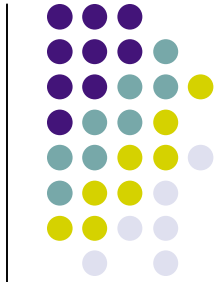
http://www.openssh.com/

Read installation instructions to check if you have pre-requisite packages and libraries.

Building and installing OpenSSH

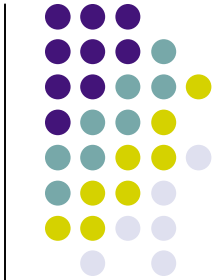


```
gtar -xzf openssh-4.5p1.tar.gz
cd openssh-4.5p1
./configure
make
make install
```



Configuration files

SSH Configuration Files



- SSH has two different sets of configuration files
  - System wide configuration files
  - User specific configuration files

System wide configuration files

- The system wide configuration are stored in `/etc/ssh` directory

`ssh_config` - Client configuration file. It is overridden by configuration file in user's home directory

`sshd_config` - Configuration file for sshd server daemon

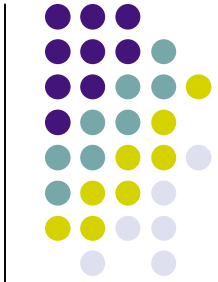
`ssh_host_dsa_key` - The DSA private key used by the sshd daemon

`ssh_host_dsa_key.pub` - The DSA public key used by the sshd daemon

`ssh_host_rsa_key` - The RSA private key used by the sshd daemon for version 2 of the SSH protocol

`ssh_host_rsa_key.pub` - The RSA public key used by the sshd for version 2 of the SSH protocol

System wide configuration files



`sshd.pid` - Server's PID is stored in this file

User specific configuration files

- The user specific configuration files are stored in `~UserName/.ssh` directory

`authorized_keys2` - This file holds a list of authorized public keys for users. When the client connects to a server, the server authenticates the client by checking its signed public key stored within this file

`id_dsa` - Contains the DSA private key of the user

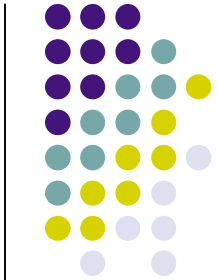
`id_dsa.pub` - The DSA public key of the user

`id_rsa` - The RSA private key of the user

`id_rsa.pub` - The RSA public key of the user

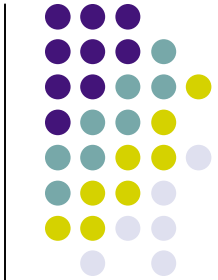
`known_hosts` - This file contains DSA host keys of SSH servers accessed by the user. This file is very important for ensuring that the SSH client is connecting the correct SSH server

User specific configuration files



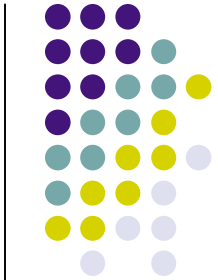
`config` - Client configuration file

Configuration files



- Specify authentication methods supported
- Specify SSH protocols supported
- Need to make trade-offs between security and easy-of use
- Behavior of the server can be controlled in following order:
  - Compiling time configuration
  - Configuration file
  - Command line options

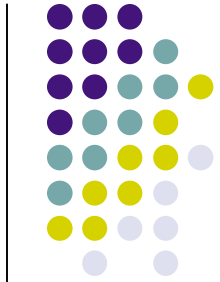
Configuration file syntax



- Server configuration is stored in `/etc/ssh/sshd_config` file
- Client configuration is stored in `/etc/ssh/ssh_config` and `~/.ssh/config` files.
- The file contains two types of entries
  - Comment or blank line
  - Key/Value pair

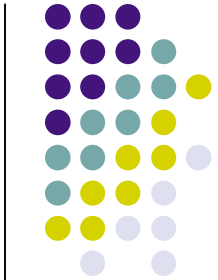
Example:

```
# This is a comment line
Port 22
```



Server Recommendations

Server recommendations



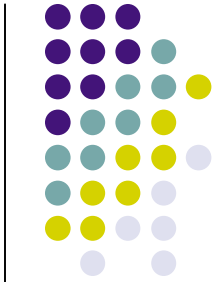
Protocol

Possible values are 1 or 2

```
Protocol 2
```

Protocol 1 has been deprecated because of vulnerabilities, it is recommended that you do not support protocol 1.

Server recommendations

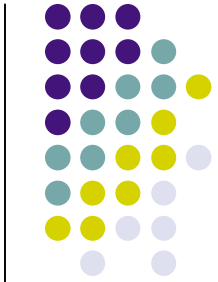


Port

Possible values are any integer less than 65535

```
Port 22
```

Server recommendations



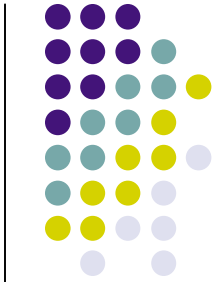
ListenAddress

IP address of the system and optionally port number

```
ListenAddress 10.90.10.101
ListenAddress 10.90.10.102:12345
```

By default sshd will listen to all network interfaces, if you want to limit sshd to service only certain interface then use this option.

Server recommendations



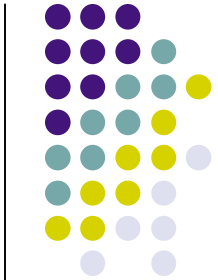
TCPKeepAlive

Send TCP keepalive messages

```
TCPKeepAlive yes
```

If keepalive messages are not sent then server may not realize that the client has crashed. It will keep running and use resources. However, this means that connections will die if the route is down temporarily.

Server recommendations



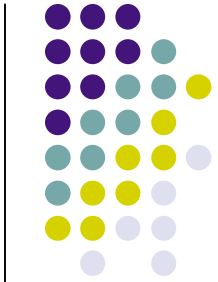
Compression

CompressionLevel

```
Compression yes
CompressionLevel 6
```

Not needed on intranet.

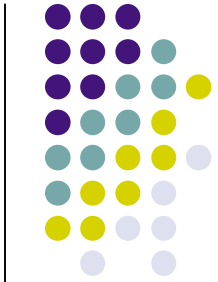
Server recommendations



IgnoreRhosts

```
IgnoreRhosts yes
```

Server recommendations

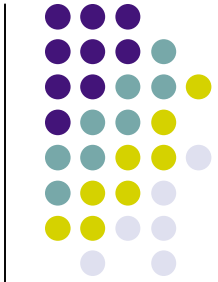


UsePrivilegeSeparation

```
UsePrivilegeSeparation yes
```

Separates privileges by creating an unprivileged child process to deal with incoming network traffic.

Server recommendations

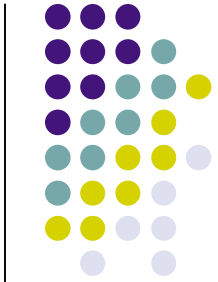


PermitRootLogin

```
PermitRootLogin no
```

Specifies whether root can login using ssh. The argument must be ``yes'', ``without-password'', ``forced-commands-only'' or ``no''. The default is ``yes''.

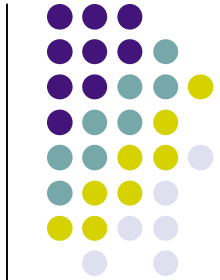
Server recommendations



Subsystem

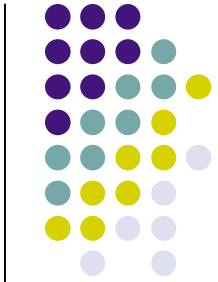
```
Subsystem sftp /usr/local/libexec/sftp-server
```

Configures external subsystem (e.g. sftp server).



Client Recommendations

Client recommendations

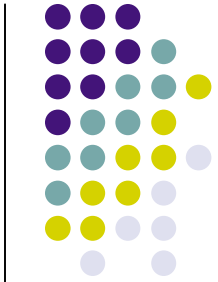


Host

`Host` *`hostname or wildcard pattern.`*

Restricts the following configuration, up to the next Host keyword, to the matching host(s).

Client recommendations

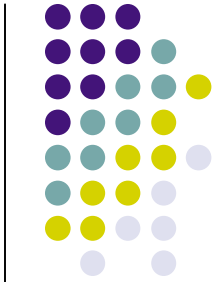


BatchMode

```
BatchMode no
```

If set to yes, passphrase/password querying is disabled. This option is useful in scripts and other batch jobs.

Client recommendations



ForwardX11

```
ForwardX11 yes
```

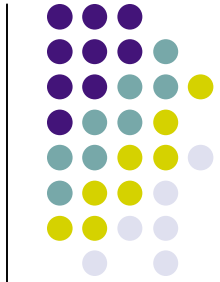
Client recommendations

ForwardX11Trusted

```
ForwardX11Trusted yes
```

If the this option is set to ``yes'' then remote X11 clients will have full access to the original X11 display. If this option is set to ``no'' then remote X11 clients will be considered untrusted and prevented from stealing or tampering with data belonging to trusted X11 clients.

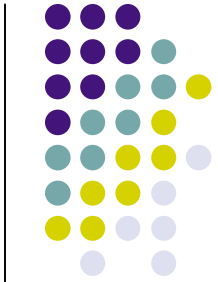
Client recommendations



IdentityFile

```
IdentityFile /path/to/private/key/file
```

Client recommendations

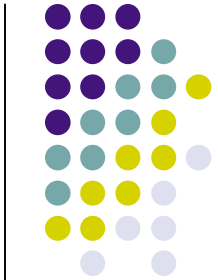


HostName

`HostName` *`real hostname or IP address`*

Specifies the real host name to log into. This can be used to specify nicknames or abbreviations for hosts.

Client recommendations

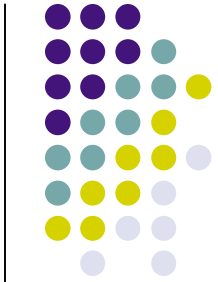


LocalForward

`LocalForward` *`port host:port`*

Specifies that a TCP/IP port on the local machine be forwarded over the secure channel to the specified host and port from the remote machine.

Client recommendations

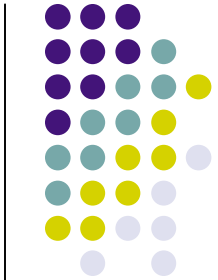


Port

`Port` *`port_number`*

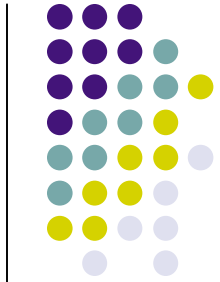
Specifies the port number to connect on the remote host.

Checking configuration



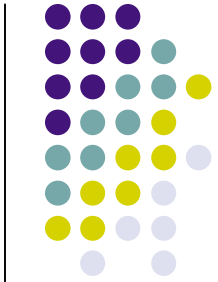
- To check the configuration run following command:

```
sshd -t
```



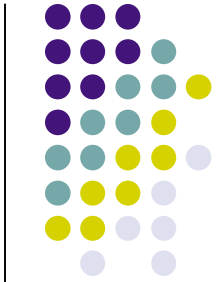
Key Management

Key pairs



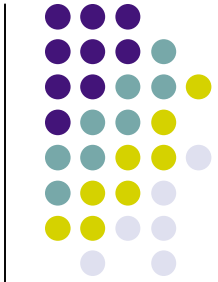
- ssh authenticates users using key pairs
  - private key
  - public key

Key management commands



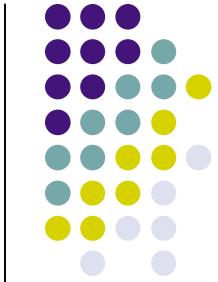
- `ssh-keygen` - Create key pairs
- `ssh-agent` - Holds private key in memory
- `ssh-add` - Adds key to the key agent

Generating key pairs



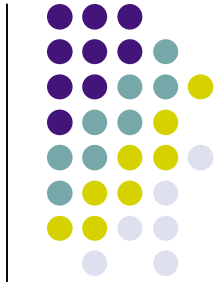
```
shahhe@kubuntu1:~$ ssh-keygen -t dsa
Generating public/private dsa key pair.
Enter file in which to save the key
(/home/shahhe/.ssh/id_dsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in
/home/shahhe/.ssh/id_dsa.
Your public key has been saved in
/home/shahhe/.ssh/id_dsa.pub.
The key fingerprint is:
99:51:ac:02:10:0c:d4:55:09:cc:86:36:cf:59:d0:33
```

Generating key pairs

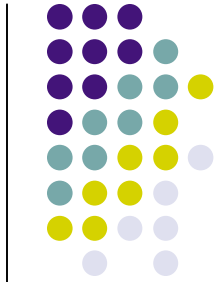


```
shahhe@kubuntu1:~$ cat ~/.ssh/id_dsa
-----BEGIN DSA PRIVATE KEY-----
MIIBuwIBAAKBgQDPmC7jSBnJMoQ8o6/cF4GUDP/gsCqonA0UGs2g/92N8qVTxxZg
U3MgZAQ96FAsaGKFDfsxoqbp1eXX7IXUS+erPOMQnDtbooLgZN3VpvStvV/hulnn
HoFJoDmoE5MnrY0Su93jZe2mPp4hOrYYQu0/8r3YRFtAzz6TCauHFxO4DQIVAJYo
apGVvbg8J1rAefSBReOef/iXAoGBAJUXbyDtR0wpyz5UKT11FmVS/a34ST9Lfzld
OjR38c9sRCf8klRZ6IuqoLUZZ3jSo56+SRsraFQReCB5GLWPx5qKzHz9xi9XFseT
aCb3Qh70EbiP3uAFqnTvk2K8voKC4dNIEXZ7SZXZUsWBImLaYXf/scvL7fMlMy9d
fCMf8By2AoGAGEdK17lrlD7zfWUVyJm+26ZaQ/QU4Yhff6Cfoe1lnq/1UmT6SEVf
SZWsj9n8fj7Ez8l03gU/g+otZXDcsS6OmNMooWkADIbkHfQ6oeoK1h/3z0hV8TY4
HnOtMZuHJMf1LPFNvINbenLS+qldGvi19aTxZUkcQJiHdpr6GR3jn9cCFE9xHd8q
Y8klJEyIPYK+KQ4UrbhZ
-----END DSA PRIVATE KEY-----
```

Generating key pairs

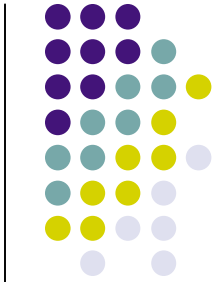


```
shahhe@kubuntu1:~$ cat ~/.ssh/id_dsa.pub
ssh-dss AAAAB3NzaC1kc3MAAACBAM+YLuNIGckyhDyjr9wXgZQM/+CwKqicDRQazaD/3Y3
ypVPHFmBTcyBkBD3oUCxoYoUN+zGipunV5dfshdRL56s84xCcO1uiguBk3dWm9K29X+G6We
cegUmgOagTkyetjRK73eNl7aY+niE6thhC7T/yvdhEW0DPPpMJq4cXE7gNAAAAFQCWKGqRl
b24PCdawHn0gUXjnn/4lwAAAIEAlRdvIO1HTCnLPlQpPXUWZVL9rfhJP0t/OV06NHfxz2xE
J/ySVFnoi6qgtRlneNKjnr5JGytoVBF4IHkYtY/HmorMfP3GL1cWx5NoJvdCHvQRuI/e4AW
qdO+TYry+goLh00gRdntJldlSxYEiYtphd/+xy8vt8yUzL118Ix/wHLYAAACAGEdK17lrlD
7zfWUVyJm+26ZaQ/QU4Yhff6Cfoe1lnq/1UmT6SEVfSZWsj9n8fj7Ez8l03gU/g+otZXDcs
S6OmNMooWkADIbkHfQ6oeoK1h/3z0hV8TY4HnOtMZuHJMf1LPFNvINbenLS+qldGvi19aTx
ZUkcQJiHdpr6GR3jn9c= shahhe@kubuntu1
```



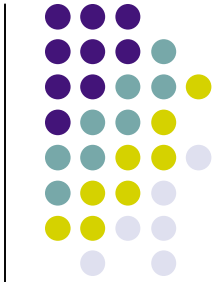
Executing commands

Logging into remote system



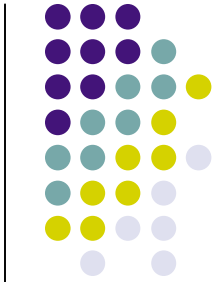
```
shahhe@kubuntu1:~$ ssh  shah@xnet.com
Last login: Mon Jun 18 21:26:33 2007 from d47-69-253-190.

* Problems? Questions?  Email:  help@xnet.com
* Type "whatsup" to see information posted to our "What's Up?"
page.

You have mail.
You have 17 read messages.
You have no new mail.

/home/customer/shah
{shah@typhoon} 1>
```

Copying file to remote system



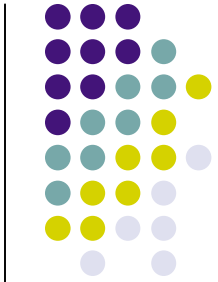
```
shahhe@kubuntu1:~$ scp .profile shah@xnet.com:tmp/profile.kubuntu
.profile                      100%  566     0.6KB/s   00:00


shahhe@kubuntu1:~$ scp shah@xnet.com:tmp/profile.kubuntu tmp/.
profile.kubuntu               100%  566     0.6KB/s   00:00
```

Executing commands on remote system

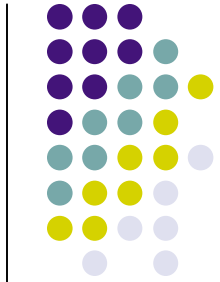


```
shahhe@kubuntu1:~$ ssh shah@xnet.com ls
Mail
News
bin
mail
public_html
tmp
```

Executing commands on remote system

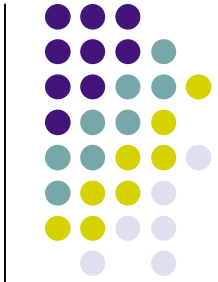


```
shahhe@kubuntu1:~$ ssh -Y shah@xnet.com /opt/sfw/bin/xterm
```



Force execution of command

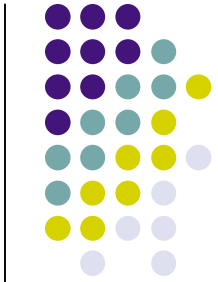
Force execution of command



- To force an execution of a command use **command** keyword in authorized_key2 file.

```
command="~/bin/DumpEmpNames",no-port-forwarding ssh-dss
AAAAB3NzaC1kc3MAAACBAIB8B1MvYlWnVeyPE6bMwrTr1OM8O2HXiQQKq9801q
fmOf9x3QYZzXVFegdNYDtN4o1sr6T7bmCNvOTC7sZoglaFIbfQoHfmIexabVyz
xin/2d2Juof7YU53Zrx1BjHKzqQpCj6jx7FxjPqlLD0BvL9R3qoPIpJ6Jt0YvY
Ae4Zj9AAAAFQDoejxCMgfZ0O/Zxwxn3mFidTpogQAAAIBDQvrhRsDFhA1UUkBO
203pVujfnNYF7X58mD/WPGZ+Z4aR8dGuD21X7hC6M8ko9a9wLLYigELSkUiWps
VZ/NJyBxhrCCD3YCNXeltJ7L0KaWGP96H2KkDtYsP7RMhAmztVpmlOrPzXbIpU
3jpq8dRJqUksG8mq2dbXPBWgh9xHyQAAAIBG9iwGfjPLDTH1niXk5tbZQUuEGk
GZzCaBw8jJlKPXMWeE7rVmBXV5sC/zhcX3OAXUNj8OUpafxFZxbxtmnzIgnehW
duWTWmiQPOi2f8oV9fCulpFnYWGNn4V4hmqDlScWNoIe3ObV05WTerdyJAY8bv
2Zfh9EJGEJvFFerdur/g== Key for Dumping active user names.
```

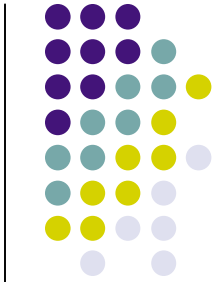
Force execution of command



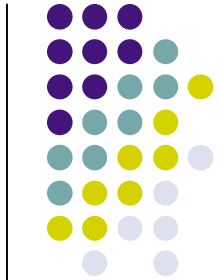
- Execute command as follows:

```
ssh -i ~/keys/DumpEmpNames.dsa user@remotehost
```

Options for authorized_keys2 file

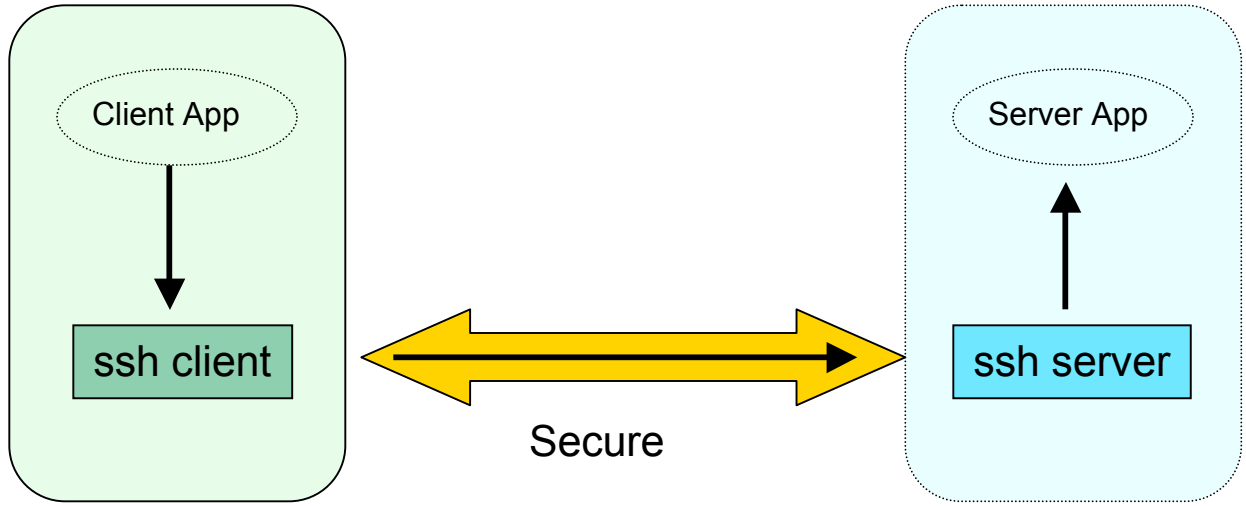


Option	Meaning
command="command name"	Specify a force command
environment="variable=value"	Set environment variable
from="host or ip address"	Limit incoming hosts
no-agent-forwarding	Disable forwarding agent
no-port-forwarding	Disable port forwarding
no-pty	Do not allocate TTY
no-x11-forwarding	Disable X11 forwarding

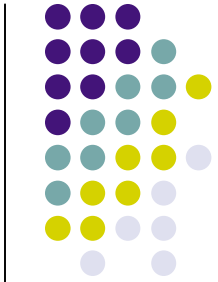


Port forwarding

Port forwarding



Port forwarding



- Create SSH tunnel

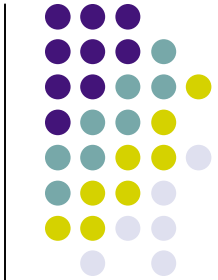
```
ssh -f -N -L10112:localhost:80 www.example.com
```

- Add to ~/.ssh/config file and run ssh command

```
Host webtunnel
   User shahhe
   Hostname www.example.com
   LocalForward 10112 www.example.com:80
```

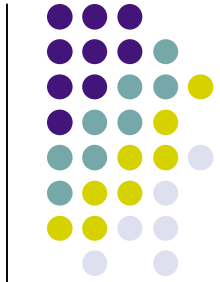
```
ssh -f -N webtunnel
```

Port forwarding



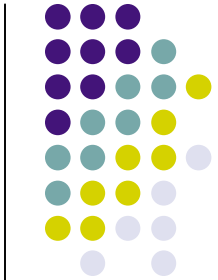
- Start application using port on localhost

```
firefox http://localhost:10112
```



Agent forwarding

Agent forwarding

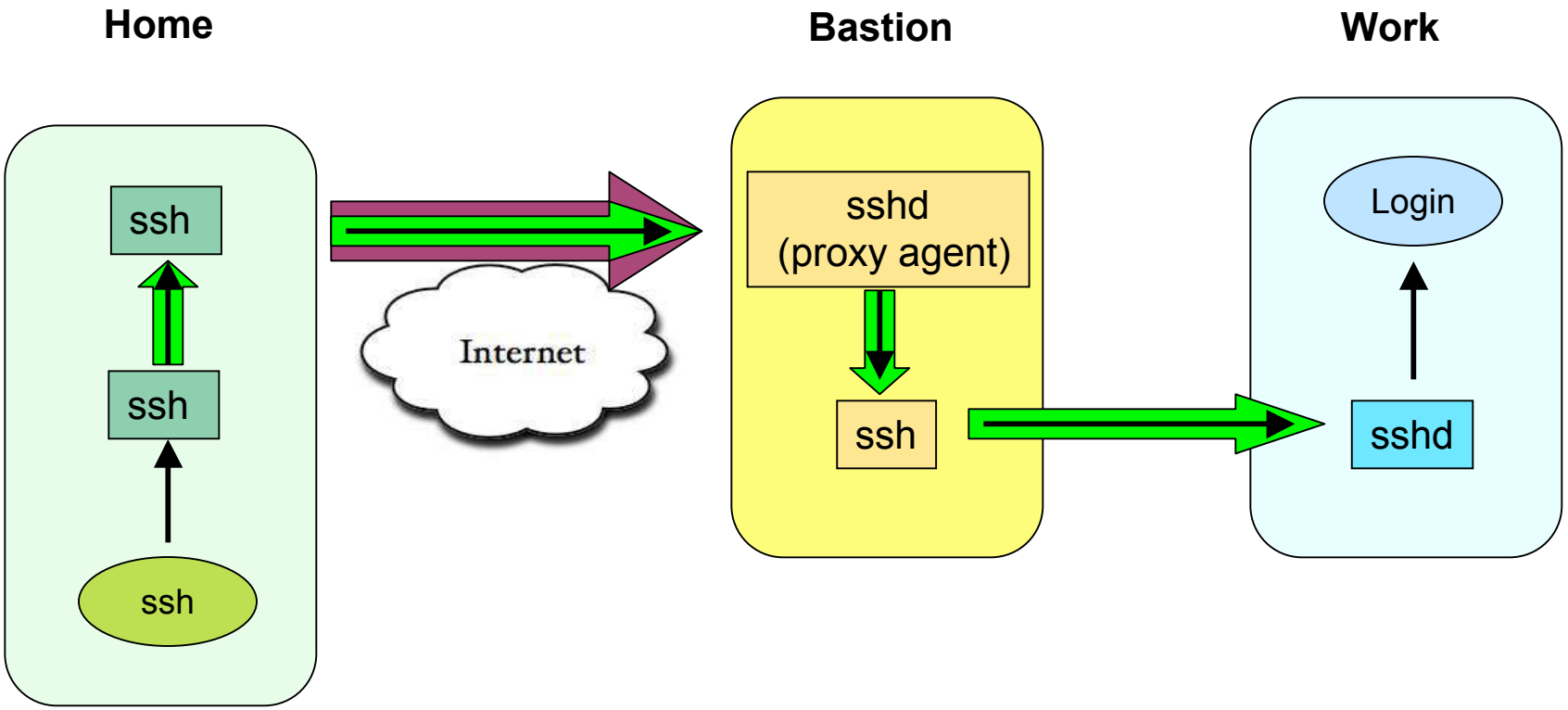


You want to login to the computer at work from your home computer or from from hotel while traveling. The computer at work is behind the firewall so you cannot connect to it directly.

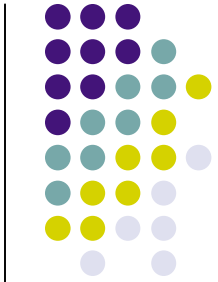
You are allowed to connect to a bastion host, but are not allowed to store private keys on it.

What can you do?

Agent Forwarding

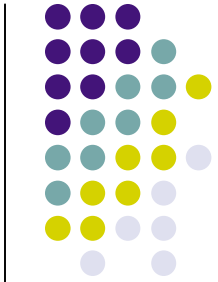


sshd configuration on bastion host



```
Port 46464
Protocol 2
PasswordAuthentication no
X11Forwarding yes
Compression no
Subsystem       sftp    /usr/libexec/sftp-server
```

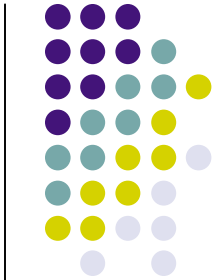
ssh tunnel configuration on home system



The configuration is stored in `~/.ssh/tunnel.cfg` file.

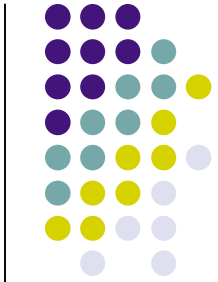
```
Host *
        ForwardX11 yes
        ForwardAgent yes
        NoHostAuthenticationForLocalhost yes

Host bastionhost
        User RemoteUser
        IdentityFile /home/LocalUser/.ssh/work_dsa
        HostName 69.2.50.60
        Port    46464
```

ssh client configuration on home system



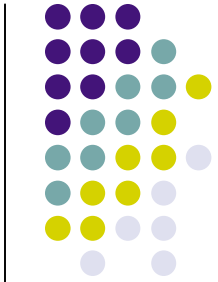
```
Host *
        ForwardX11 yes
        ForwardAgent yes
        NoHostAuthenticationForLocalhost yes

Host portmap
        HostName localhost
        LocalForward 10001 10.60.80.101:22
        LocalForward 10002 10.60.80.102:22

Host host1
        User RemoteUser
        IdentityFile /home/LocalUser/.ssh/work_dsa
        HostName localhost
        Port 10001

Host host2
        User RemoteUser
        IdentityFile /home/LocalUser/.ssh/work_dsa
        HostName localhost
        Port 10002
```

Setting Key Pair



- Generate key with password
- Store private key on **Home** system
- Store public key on **Bastion** host
- Store public key on **Work** system

Login into work systems



Do the following on the HOME system:

- Start ssh-agent and add the key

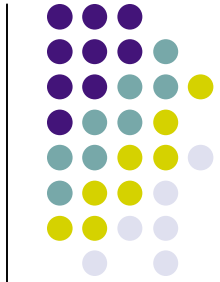
```
ssh-agent $SHELL
ssh-add ~/.ssh/work_dsa
```

- Create tunnel to bastion host

```
ssh -f -N -F ~/.ssh/tunnel.cfg bastionhost
ssh -f -N UserName@portmap
```

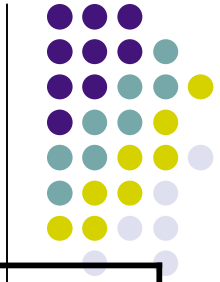
- Login in to work systems

```
ssh host1
ssh host2
```

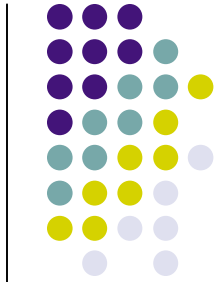


Environment variables

Environment variables

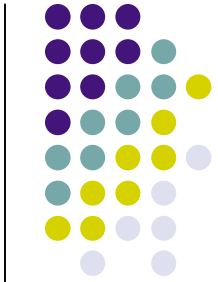


Variable	Meaning	Example
SSH_CONNECTION	Client and server socket information	10.90.10.107 45756 10.90.10.182 22
SSH_AUTH_SOCK	Path to socket	/tmp/ssh-FcRCI22249/agent.22249
SSH_CLIENT	Client socket information	10.90.10.107 45756 22
SSH_TTY	Name of TTY	/dev/pts/48



Other ssh based applications

Other ssh based applications



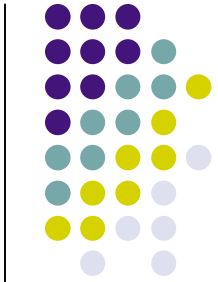
- sshfs - ssh based file system client

  `http://fuse.sourceforge.net/sshfs.html`

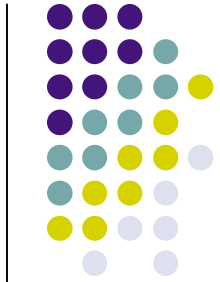
- sftp - secure file transfer. Part of OpenSSH

  `http://www.openssh.com/`

OpenSSH alternatives for windows

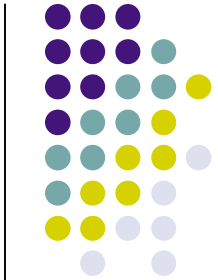


PuTTY
TTSSH
Cygwin
MSSH
WinSCP
FileZilla

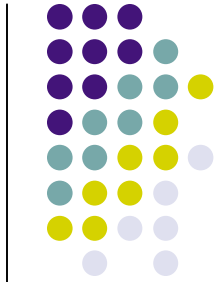


Advantages of using ssh

Advantages

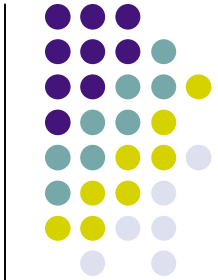


- Proven technology
- Strong encryption
- Both free and commercial versions exist
- Runs on many platforms
- Tunneling of ports works well and can be used for simple VPNs
- Many authentication methods supported
- Can be SOCKS5 proxy aware
- Use it instead of VPN



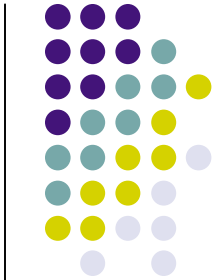
Disadvantages of using ssh

Disadvantages



- Port ranges & dynamic ports can't be forwarded
- SSH server daemon:
  - Cannot restrict what ports may or may not be forwarded, per user
  - When a user is authenticated by password, the client's RSA identity is not verified (against ssh_known_hosts). The verification only takes place when .[sr]hosts trust is used
- Port forwarding can also introduce security problems. The SSH server doesn't allow detailed configuration of what forwarding is allowed from what client to what server etc.
- A client on the Internet that uses SSH to access the Intranet, can expose the Intranet by port forwarding

Resources



http://www.openssh.com/

http://fuse.sourceforge.net/sshfs.html

Barrett, D., Silverman, R., & Byrnes, R. (2005). SSH The Definitive Guide, Second Edition. O'Reilly Media, Inc.

SSH FAQ
http://www.employees.org/~satch/ssh/faq/ssh-faq.html