CS 827: Lab 2

Due on Wednesday, April 8, 2020

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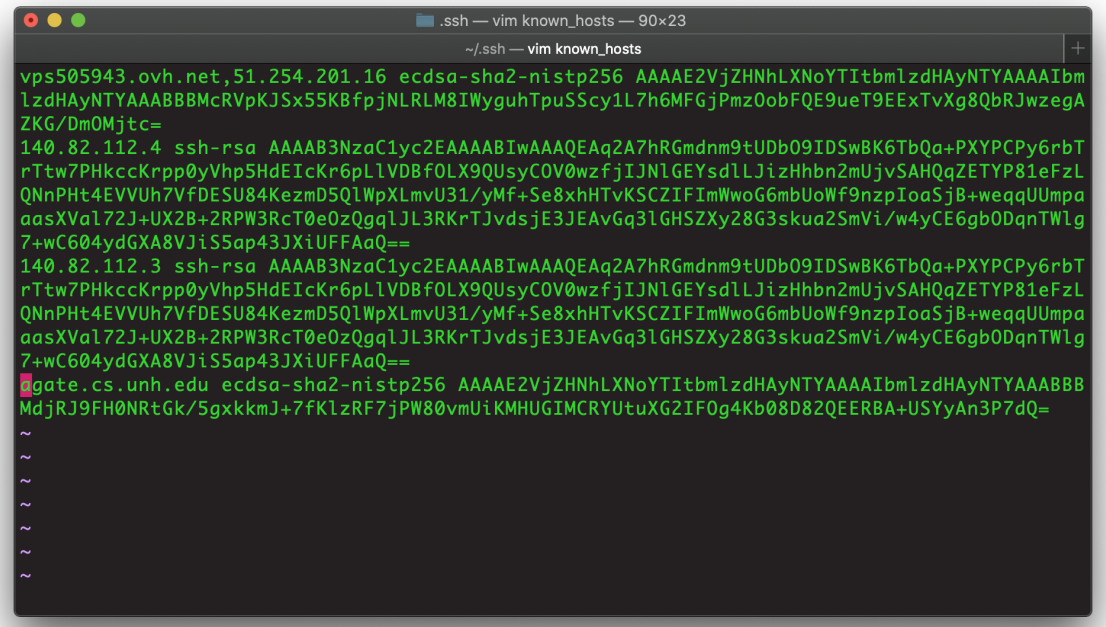
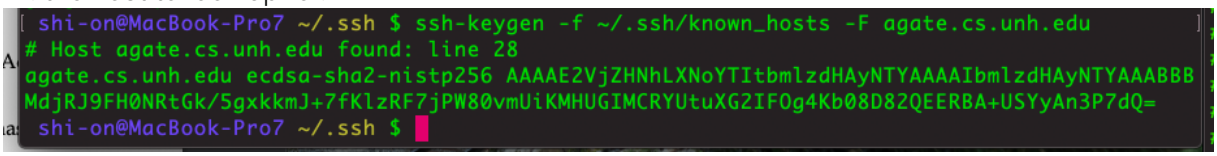
1 Protocol

1. As I have OpenSSH pre-installed on my machine, I have logged in to Agate through SSH. I have Agate's public key stored in the list of my known hosts already. As you it is shown below, the Agate's public key (hashed in SHA256) is existing in my local machine's `known_hosts` file:



2. The following command confirms that that the Agate's public key is stored on my machine:
`ssh-keygen -f /.ssh/known_hosts -F agate.cs.unh.edu`
-f: file name to look up in.
-F: the host to look up for.



3. My SSH client queries including the **ciphers**, **MACs**, and **key-exchange algorithms** supported by **my local SSH client**:

```
shi-on@MacBook-Pro7 ~/.ssh $ ssh -Q cipher
3des-cbc
aes128-cbc
aes192-cbc
aes256-cbc
rijndael-cbc@lysator.liu.se
aes128-ctr
aes192-ctr
aes256-ctr
aes128-gcm@openssh.com
aes256-gcm@openssh.com
chacha20-poly1305@openssh.com
shi-on@MacBook-Pro7 ~/.ssh $ ssh -Q mac
hmac-sha1
hmac-sha1-96
hmac-sha2-256
hmac-sha2-512
hmac-md5
hmac-md5-96
umac-64@openssh.com
umac-128@openssh.com
hmac-sha1-etm@openssh.com
hmac-sha1-96-etm@openssh.com
hmac-sha2-256-etm@openssh.com
hmac-sha2-512-etm@openssh.com
hmac-md5-etm@openssh.com
hmac-md5-96-etm@openssh.com
umac-64-etm@openssh.com
umac-128-etm@openssh.com
shi-on@MacBook-Pro7 ~/.ssh $ ssh -Q kex
diffie-hellman-group1-sha1
diffie-hellman-group14-sha1
diffie-hellman-group14-sha256
diffie-hellman-group16-sha512
diffie-hellman-group18-sha512
diffie-hellman-group-exchange-sha1
diffie-hellman-group-exchange-sha256
ecdh-sha2-nistp256
ecdh-sha2-nistp384
ecdh-sha2-nistp521
curve25519-sha256
curve25519-sha256@libssh.org
sntrup4591761x25519-sha512@tinyssh.org
```

4. SSH in verbose mode:

```
shi-on@MacBook-Pro7 ~/.ssh $ ssh -vv sa1149@agate.cs.unh.edu
OpenSSH_8.1p1, LibreSSL 2.7.3
debug1: Reading configuration data /etc/ssh/ssh_config
debug1: /etc/ssh/ssh_config line 47: Applying options for *
debug1: Connecting to agate.cs.unh.edu port 22.
debug1: Connection established.
debug1: identity file /Users/shi-on/.ssh/id_rsa type 0
```

```
debug1: identity file /Users/shi-on/.ssh/id_rsa-cert type -1
debug1: identity file /Users/shi-on/.ssh/id_dsa type -1
debug1: identity file /Users/shi-on/.ssh/id_dsa-cert type -1
debug1: identity file /Users/shi-on/.ssh/id_ecdsa type -1
debug1: identity file /Users/shi-on/.ssh/id_ecdsa-cert type -1
debug1: identity file /Users/shi-on/.ssh/id_ed25519 type -1
debug1: identity file /Users/shi-on/.ssh/id_ed25519-cert type -1
debug1: identity file /Users/shi-on/.ssh/id_xmss type -1
debug1: identity file /Users/shi-on/.ssh/id_xmss-cert type -1
debug1: Local version string SSH-2.0-OpenSSH_8.1
debug1: Remote protocol version 2.0, remote software version OpenSSH_8.1
debug1: match: OpenSSH_8.1 pat OpenSSH* compat 0x04000000
debug1: Authenticating to agate.cs.unh.edu:22 as 'sa1149'
debug1: SSH2_MSG_KEXINIT sent
debug1: SSH2_MSG_KEXINIT received
debug2: local client KEXINIT proposal
debug2: KEX algorithms: curve25519-sha256,curve25519-sha256@libssh.org,ecdh-sha2-
    nistp256,ecdh-sha2-nistp384,ecdh-sha2-nistp521,diffie-hellman-group-exchange-
    sha256,diffie-hellman-group16-sha512,diffie-hellman-group18-sha512,diffie-
    hellman-group14-sha256,diffie-hellman-group14-sha1,ext-info-c
debug2: host key algorithms: ecdsa-sha2-nistp256-cert-v01@openssh.com,ecdsa-sha2-
    nistp384-cert-v01@openssh.com,ecdsa-sha2-nistp521-cert-v01@openssh.com,ecdsa-
    sha2-nistp256,ecdsa-sha2-nistp384,ecdsa-sha2-nistp521,ssh-ed25519-cert-
    v01@openssh.com,rsa-sha2-512-cert-v01@openssh.com,rsa-sha2-256-cert-v01@openssh.
    com,ssh-rsa-cert-v01@openssh.com,ssh-ed25519,rsa-sha2-512,rsa-sha2-256,ssh-rsa
debug2: ciphers ctos: chacha20-poly1305@openssh.com,aes128-ctr,aes192-ctr,aes256-ctr
    ,aes128-gcm@openssh.com,aes256-gcm@openssh.com
debug2: ciphers stoc: chacha20-poly1305@openssh.com,aes128-ctr,aes192-ctr,aes256-ctr
    ,aes128-gcm@openssh.com,aes256-gcm@openssh.com
debug2: MACs ctos: umac-64-etm@openssh.com,umac-128-etm@openssh.com,hmac-sha2-256-
    etm@openssh.com,hmac-sha2-512-etm@openssh.com,hmac-sha1-etm@openssh.com,umac-64
    @openssh.com,umac-128@openssh.com,hmac-sha2-256,hmac-sha2-512,hmac-sha1
debug2: MACs stoc: umac-64-etm@openssh.com,umac-128-etm@openssh.com,hmac-sha2-256-
    etm@openssh.com,hmac-sha2-512-etm@openssh.com,hmac-sha1-etm@openssh.com,umac-64
    @openssh.com,umac-128@openssh.com,hmac-sha2-256,hmac-sha2-512,hmac-sha1
debug2: compression ctos: none,zlib@openssh.com,zlib
debug2: compression stoc: none,zlib@openssh.com,zlib
debug2: languages ctos:
debug2: languages stoc:
debug2: first_kex_follows 0
debug2: reserved 0
debug2: peer server KEXINIT proposal
debug2: KEX algorithms: curve25519-sha256,curve25519-sha256@libssh.org,ecdh-sha2-
    nistp256,ecdh-sha2-nistp384,ecdh-sha2-nistp521,diffie-hellman-group-exchange-
    sha256,diffie-hellman-group14-sha256,diffie-hellman-group16-sha512,diffie-
    hellman-group18-sha512,diffie-hellman-group-exchange-sha1,diffie-hellman-group14
    -sha1
debug2: host key algorithms: rsa-sha2-512,rsa-sha2-256,ssh-rsa,ecdsa-sha2-nistp256,
    ssh-ed25519
debug2: ciphers ctos: aes256-gcm@openssh.com,chacha20-poly1305@openssh.com,aes256-
    ctr,aes256-cbc,aes128-gcm@openssh.com,aes128-ctr,aes128-cbc
debug2: ciphers stoc: aes256-gcm@openssh.com,chacha20-poly1305@openssh.com,aes256-
    ctr,aes256-cbc,aes128-gcm@openssh.com,aes128-ctr,aes128-cbc
debug2: MACs ctos: hmac-sha2-256-etm@openssh.com,hmac-sha1-etm@openssh.com,umac-128-
    etm@openssh.com,hmac-sha2-512-etm@openssh.com,hmac-sha2-256,hmac-sha1,umac-128
    @openssh.com,hmac-sha2-512
debug2: MACs stoc: hmac-sha2-256-etm@openssh.com,hmac-sha1-etm@openssh.com,umac-128-
    etm@openssh.com,hmac-sha2-512-etm@openssh.com,hmac-sha2-256,hmac-sha1,umac-128
    @openssh.com,hmac-sha2-512
debug2: compression ctos: none,zlib@openssh.com
debug2: compression stoc: none,zlib@openssh.com
```

```
debug2: languages ctos:
debug2: languages stoc:
debug2: first_kex_follows 0
debug2: reserved 0
debug1: kex: algorithm: curve25519-sha256
debug1: kex: host key algorithm: ecdsa-sha2-nistp256
debug1: kex: server->client cipher: chacha20-poly1305@openssh.com MAC: <implicit>
    compression: none
debug1: kex: client->server cipher: chacha20-poly1305@openssh.com MAC: <implicit>
    compression: none
debug1: expecting SSH2_MSG_KEX_ECDH_REPLY
debug1: Server host key: ecdsa-sha2-nistp256 SHA256:9/iGsnFwRo+
    Y5rFvcgAenpWV68T3LlclnhhycYTXtr8
debug1: Host 'agate.cs.unh.edu' is known and matches the ECDSA host key.
debug1: Found key in /Users/shi-on/.ssh/known_hosts:28
debug2: set_newkeys: mode 1
debug1: rekey out after 134217728 blocks
debug1: SSH2_MSG_NEWKEYS sent
debug1: expecting SSH2_MSG_NEWKEYS
debug1: SSH2_MSG_NEWKEYS received
debug2: set_newkeys: mode 0
debug1: rekey in after 134217728 blocks
debug1: Will attempt key: /Users/shi-on/.ssh/id_rsa RSA SHA256:hxXIAqYgANs++5
    HrJTj9qymB5tqH2aAwQUHSc9PAGcU
debug1: Will attempt key: /Users/shi-on/.ssh/id_dsa
debug1: Will attempt key: /Users/shi-on/.ssh/id_ecdsa
debug1: Will attempt key: /Users/shi-on/.ssh/id_ed25519
debug1: Will attempt key: /Users/shi-on/.ssh/id_xmss
debug2: pubkey_prepare: done
debug1: SSH2_MSG_EXT_INFO received
debug1: kex_input_ext_info: server-sig-algs=<ssh-ed25519,ssh-rsa,rsa-sha2-256,rsa-
    sha2-512,ssh-dss,ecdsa-sha2-nistp256,ecdsa-sha2-nistp384,ecdsa-sha2-nistp521>
debug2: service_accept: ssh-userauth
debug1: SSH2_MSG_SERVICE_ACCEPT received
debug1: Authentications that can continue: publickey,gssapi-keyex,gssapi-with-mic,
    password
debug1: Next authentication method: publickey
debug1: Offering public key: /Users/shi-on/.ssh/id_rsa RSA SHA256:hxXIAqYgANs++5
    HrJTj9qymB5tqH2aAwQUHSc9PAGcU
debug2: we sent a publickey packet, wait for reply
debug1: Server accepts key: /Users/shi-on/.ssh/id_rsa RSA SHA256:hxXIAqYgANs++5
    HrJTj9qymB5tqH2aAwQUHSc9PAGcU
debug1: Authentication succeeded (publickey).
Authenticated to agate.cs.unh.edu ([132.177.4.36]:22).
debug1: channel 0: new [client-session]
debug2: channel 0: send open
debug1: Requesting no-more-sessions@openssh.com
debug1: Entering interactive session.
debug1: pledge: network
debug1: client_input_global_request: rtype hostkeys-00@openssh.com want_reply 0
debug1: Remote: /home/csg/sa1149/.ssh/authorized_keys:1: key options: agent-
    forwarding port-forwarding pty user-rc x11-forwarding
debug1: Remote: /home/csg/sa1149/.ssh/authorized_keys:1: key options: agent-
    forwarding port-forwarding pty user-rc x11-forwarding
debug2: channel_input_open_confirmation: channel 0: callback start
debug2: fd 5 setting TCP_NODELAY
debug2: client_session2_setup: id 0
debug2: channel 0: request pty-req confirm 1
debug1: Sending environment.
debug1: Sending env LANG = en_US.UTF-8
debug2: channel 0: request env confirm 0
```

```
debug2: channel 0: request shell confirm 1
debug2: channel_input_open_confirmation: channel 0: callback done
debug2: channel 0: open confirm rwindow 0 rmax 32768
debug2: channel_input_status_confirm: type 99 id 0
debug2: PTY allocation request accepted on channel 0
debug2: channel 0: rcvd adjust 2097152
debug2: channel_input_status_confirm: type 99 id 0
debug2: shell request accepted on channel 0
/**
 * Please read /etc/motd.ssh for an important notice
 * regarding ssh access to agate
**/
Last login: Mon Apr  6 14:44:04 2020 from 67.189.133.88
/**
 * Please read /etc/motd.ssh for an important notice
 * regarding ssh access to agate
**/
[sa1149@agate ~]$
```

I have listed the ciphers used in the exchange. As the authentication to ssh server goes in two steps we can see two set of used ciphers for each side which adds up to 4 sets. **Ciphers used from client to server (ctos) and from server to client (stoc)**:

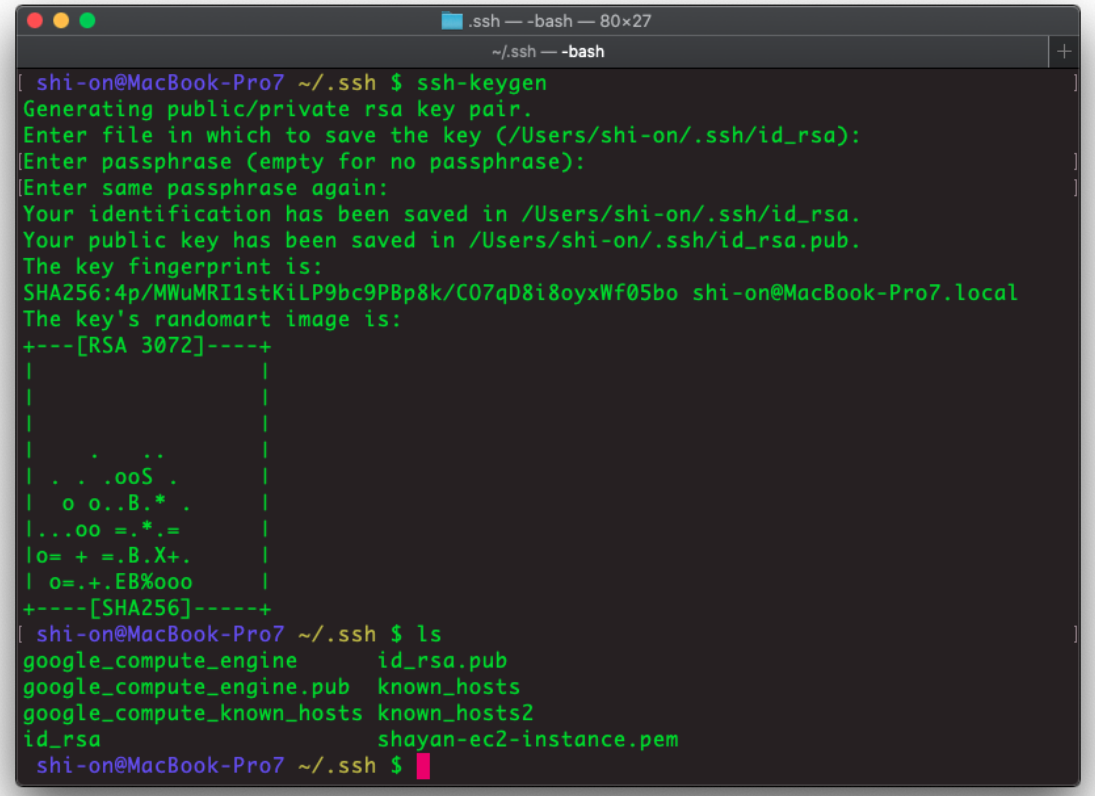
```
ciphers client->server:
chacha20-poly1305@openssh.com,
aes128-ctr,
aes192-ctr,
aes256-ctr,
aes128-gcm@openssh.com,
aes256-gcm@openssh.com

ciphers server->client:
chacha20-poly1305@openssh.com,
aes128-ctr,
aes192-ctr,
aes256-ctr,
aes128-gcm@openssh.com,
aes256-gcm@openssh.com



ciphers client->server:
aes256-gcm@openssh.com,
chacha20-poly1305@openssh.com,
aes256-ctr,
aes256-cbc,
aes128-gcm@openssh.com,
aes128-ctr,
aes128-cbc

ciphers server->client:
aes256-gcm@openssh.com,
chacha20-poly1305@openssh.com,
aes256-ctr,
aes256-cbc,
aes128-gcm@openssh.com,
aes128-ctr,
aes128-cbc
```

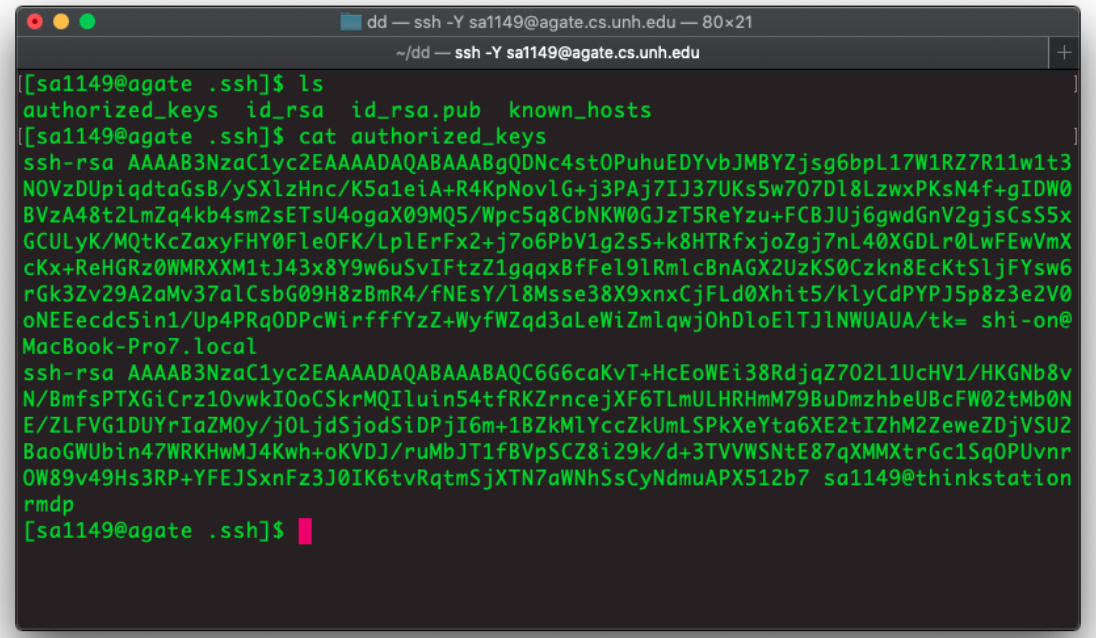
5. ciphers, **MACs**, and **key-exchange algorithms** supported by **Agate**:

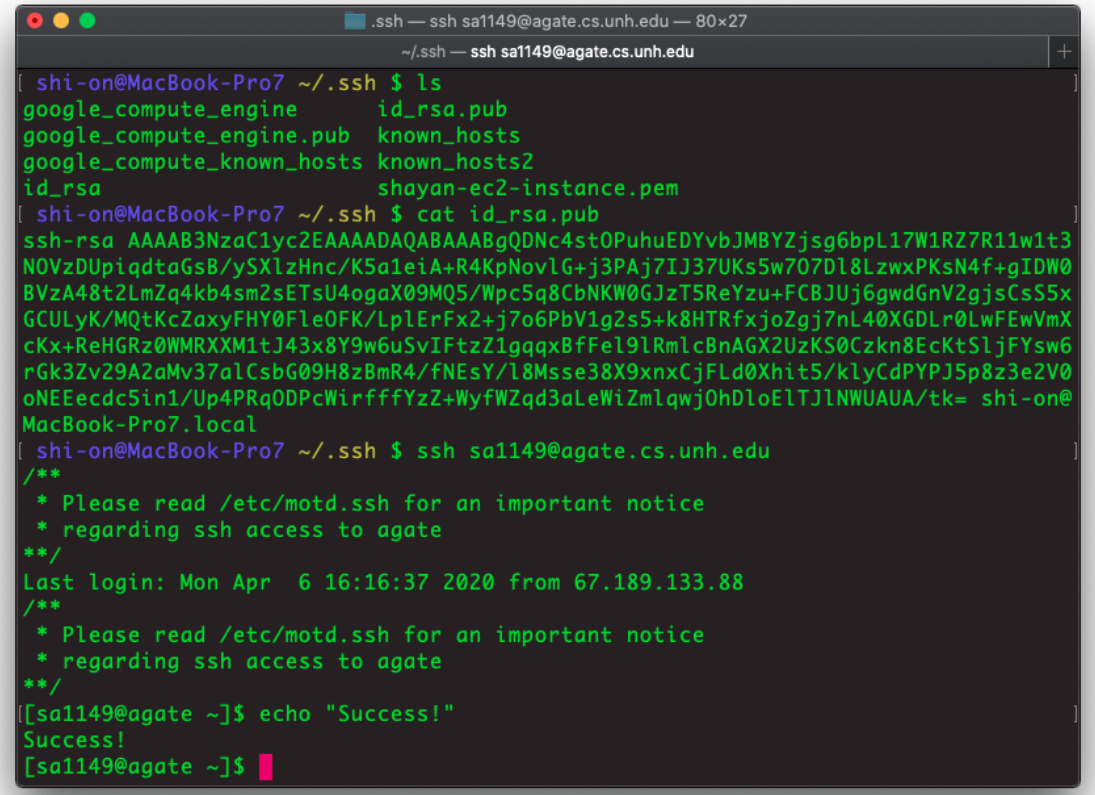
```
[sa1149@agate ~]$ ssh -Q cipher
3des-cbc
aes128-cbc
aes192-cbc
aes256-cbc
rijndael-cbc@lysator.liu.se
aes128-ctr
aes192-ctr
aes256-ctr
aes128-gcm@openssh.com
aes256-gcm@openssh.com
chacha20-poly1305@openssh.com
[sa1149@agate ~]$ ssh -Q mac
hmac-sha1
hmac-sha1-96
hmac-sha2-256
hmac-sha2-512
hmac-md5
hmac-md5-96
umac-64@openssh.com
umac-128@openssh.com
hmac-sha1-etm@openssh.com
hmac-sha1-96-etm@openssh.com
hmac-sha2-256-etm@openssh.com
hmac-sha2-512-etm@openssh.com
hmac-md5-etm@openssh.com
hmac-md5-96-etm@openssh.com
umac-64-etm@openssh.com
umac-128-etm@openssh.com
[sa1149@agate ~]$ ssh -Q kex
diffie-hellman-group1-sha1
diffie-hellman-group14-sha1
diffie-hellman-group14-sha256
diffie-hellman-group16-sha512
diffie-hellman-group18-sha512
diffie-hellman-group-exchange-sha1
diffie-hellman-group-exchange-sha256
ecdh-sha2-nistp256
ecdh-sha2-nistp384
ecdh-sha2-nistp521
curve25519-sha256
curve25519-sha256@libssh.org
sntrup4591761x25519-sha512@tinyssh.org
[sa1149@agate ~]$
```

6. Generate a key pair locally and place it on Agate in order to login to Agate without password:

1. on the local machine
2. on Agate
3. login without password




dd — ssh -Y sa1149@agate.cs.unh.edu — 80×21
~/dd — ssh -Y sa1149@agate.cs.unh.edu
[sa1149@agate .ssh]$ ls
authorized_keys id_rsa id_rsa.pub known_hosts
[sa1149@agate .ssh]$ cat authorized_keys
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQDNc4stOPuhuEDYvbJMBYZjsg6bpL17W1RZ7R11w1t3
NOVzDUpiqdtaGsB/ySXlzHnc/K5a1eiA+R4KpNovlG+j3PAj7IJ37UKs5w7O7Dl8LzwxPKsN4f+gIDW0
BVzA48t2LmZq4kb4sm2sETsU4ogaX09MQ5/Wpc5q8CbNKW0GJzT5ReYzu+FCBJUj6gwdGnV2gjsCsS5x
GCULyK/MQtKcZaxyFHY0FleOFK/LplErFx2+j7o6PbV1g2s5+k8HTRfxjoZgj7nL40XGDLr0LwFEwVmX
cKx+ReHGRz0WMRXXM1tJ43x8Y9w6uSvIFtzZ1gqqxBfFel9lRmlcBnAGX2UzKS0Czkn8EcKtSljFYsw6
rGk3Zv29A2aMv37alCsbG09H8zBmR4/fNEsY/l8Msse38X9xnxCjFLd0Xhit5/klyCdPYPJ5p8z3e2V0
oNEEecdc5in1/Up4PRqODPcWirfffYzZ+WyfWZqd3aLeWiZmlqwjOhDloElTJlNWUAUA/tk= shi-on@
MacBook-Pro7.local
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQC6G6caKvT+HcEoWEi38RdjqZ7O2L1UcHV1/HKGNb8v
N/BmfsPTXGiCrz1OvwkIOoCSkrMQIluin54tfRKZrncejXF6TLmULHRHmM79BuDmzhbeUBcFW02tMb0N
E/ZLFVG1DUYrIaZMOy/jOLjdSjodSiDPjI6m+1BZkMlYccZkUmLSPkXeYta6XE2tIZhM2ZeweZDjVSU2
BaoGWUbin47WRKHwMJ4Kwh+oKVDJ/ruMbJT1fBVpSCZ8i29k/d+3TVVWSNtE87qXMMXtrGc1SqOPUvnr
OW89v49Hs3RP+YFEJSxnFz3J0IK6tvRqtmSjXTN7aWNhSsCyNdmuAPX512b7 sa1149@thinkstation
rmdp
[sa1149@agate .ssh]$


.ssh — ssh sa1149@agate.cs.unh.edu — 80×27
~/.ssh — ssh sa1149@agate.cs.unh.edu
[shi-on@MacBook-Pro7 ~/.ssh $ ls
google_compute_engine id_rsa.pub
google_compute_engine.pub known_hosts
google_compute_known_hosts known_hosts2
id_rsa shayan-ec2-instance.pem
[shi-on@MacBook-Pro7 ~/.ssh $ cat id_rsa.pub
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABgQDNc4stOPuhuEDYvbJMBYZjsg6bpL17W1RZ7R11w1t3
NOVzDUpiqdtaGsB/ySXlzHnc/K5a1eiA+R4KpNovlG+j3PAj7IJ37UKs5w7O7Dl8LzwxPKsN4f+gIDW0
BVzA48t2LmZq4kb4sm2sETsU4ogaX09MQ5/Wpc5q8CbNKW0GJzT5ReYzu+FCBJUj6gwdGnV2gjsCsS5x
GCULyK/MQtKcZaxyFHY0FleOFK/LplErFx2+j7o6PbV1g2s5+k8HTRfxjoZgj7nL40XGDLr0LwFEwVmX
cKx+ReHGRz0WMRXXM1tJ43x8Y9w6uSvIFtzZ1gqqxBfFel9lRmlcBnAGX2UzKS0Czkn8EcKtSljFYsw6
rGk3Zv29A2aMv37alCsbG09H8zBmR4/fNEsY/l8Msse38X9xnxCjFLd0Xhit5/klyCdPYPJ5p8z3e2V0
oNEEecdc5in1/Up4PRqODPcWirfffYzZ+WyfWZqd3aLeWiZmlqwjOhDloElTJlNWUAUA/tk= shi-on@
MacBook-Pro7.local
[shi-on@MacBook-Pro7 ~/.ssh $ ssh sa1149@agate.cs.unh.edu
/**
* Please read /etc/motd.ssh for an important notice
* regarding ssh access to agate
**/
Last login: Mon Apr 6 16:16:37 2020 from 67.189.133.88
/**
* Please read /etc/motd.ssh for an important notice
* regarding ssh access to agate
**/
[sa1149@agate ~]$ echo "Success!"
Success!
[sa1149@agate ~]$

2 Password

1. I have used my VPS as a Linux machine which has **CentOS Linux release 7.7.1908 (Core)** installed. I created a new user 'victim' and set '123' as the password for this user:

```
(base) [root@vps505943 run]# adduser victim
(base) [root@vps505943 run]# passwd
Changing password for user root.
New password:
(base) [root@vps505943 run]# setpasswd
-bash: setpasswd: command not found
(base) [root@vps505943 run]# passwd victim
Changing password for user victim.
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: all authentication tokens updated successfully.
(base) [root@vps505943 run]# ls
```

2. As the shadow file is visible below, I have two hashed passwords in the file for the two users available on this machine.
Explanation of the fields available in the shadow file, in order from left to right:

1. username
2. password:
   (a) hashing algorithm id: 1 -> MD5
   (b) salt
   (c) hashed value
3. last change
4. min days change
5. max days change
6. prior warning days

```
(base) [root@vps505943 etc]# cat shadow
root:$1$6ZBEvvpH$S7hpskujc0aqp46162IlU0:18277:0:99999:7:::
bin:*:17834:0:99999:7:::
daemon:*:17834:0:99999:7:::
adm:*:17834:0:99999:7:::
lp:*:17834:0:99999:7:::
sync:*:17834:0:99999:7:::
shutdown:*:17834:0:99999:7:::
halt:*:17834:0:99999:7:::
mail:*:17834:0:99999:7:::
operator:*:17834:0:99999:7:::
games:*:17834:0:99999:7:::
ftp:*:17834:0:99999:7:::
nobody:*:17834:0:99999:7:::
systemd-network:!!:18231::::::
dbus:!!:18231::::::
polkitd:!!:18231::::::
sshd:!!:18231::::::
postfix:!!:18231::::::
chrony:!!:18231::::::
centos:!!:18268:0:99999:7:::
mysql:!!:18268::::::
saslauth:!!:18268::::::
dovecot:!!:18268::::::
dovenull:!!:18268::::::
tss:!!:18268::::::
named:!!:18268::::::
cwpsrv:!!:18268::::::
cwpsvc:!!:18268::::::
login:!!:18268::::::
clamupdate:!!:18268::::::
amavis:!!:18268::::::
clamscan:!!:18268::::::
vmail:!!:18268::::::
vacation:!!:18268::::::
opendkim:!!:18268::::::
rpc:!!:18268:0:99999:7:::
nginx:!!:18268::::::
deluge:!!:18268::::::
victim:$1$jbtxaOtD$TiEBhdPGR0XlcUfehp4sv0:18358:0:99999:7:::
(base) [root@vps505943 etc]#
```

3. I installed John the Ripper 1.8 by taking the following steps.

```
#!/bin/bash
# Centos 7 John the Ripper Installation
yum -y install wget gpgme
yum -y group install "Development Tools"
cd
wget http://www.openwall.com/john/j/john-1.8.0.tar.xz
wget http://www.openwall.com/john/j/john-1.8.0.tar.xz.sign
wget http://www.openwall.com/signatures/openwall-signatures.asc
gpg --import openwall-signatures.asc
```

```
gpg --verify john-1.8.0.tar.xz.sign
tar xvfJ john-1.8.0.tar.xz
cd john-1.8.0/src
make clean linux-x86-64
cd ../run/
./john --test
#password dictionnary download
wget -O - http://mirrors.kernel.org/openwall/wordlists/all.gz | gunzip -c > openwall
    .dico
```

4. After the installation, I used JtR to crack victim's password. As this was a very common and unsafe password, we don't even need to use a prolific word list. As it is displayed in the following graph JtR could quickly find the password, '123':

```
(base) [root@vps505943 run]# ls
ascii.chr   john.conf  john.rec      makechr        relbench  unshadow
digits.chr  john.log   lm_ascii.chr  openwall.dico  unafs
john        john.pot   mailer        password.lst   unique
(base) [root@vps505943 run]# cp /etc/shadow .
(base) [root@vps505943 run]# ./john shadow
Loaded 2 password hashes with 2 different salts (md5crypt [MD5 32/64 X2])
Press 'q' or Ctrl-C to abort, almost any other key for status
123              (victim)
1g 0:00:00:05 41% 2/3 0.2000g/s 14413p/s 14417c/s 14417C/s cssndr..rdsx
Use the "--show" option to display all of the cracked passwords reliably
Session aborted
(base) [root@vps505943 run]#
```