# SSH -- Secure Shell

Discussion Notes

rev4

Cyber Security Forum

nebraskacert.org/CSF/

# Some SSH Hardening

- Many SSH installations have dangerous default settings enabled.
- This talk discusses some of these vulnerabilities, how to check for them, and ways to mitigate them.

- Additionally, some good practices (and handy tricks!) for using SSH to improve security are proposed and demonstrated.

# Why does this happen?

- Just as older httpd installations have default settings that are now considered bad practices, many sshd installations have default settings that present vulnerable attack surfaces.
- TAM, features, and easy of use

# About

- Speaker:
  - Matt Payne, CISSP
  - Contact: Payne@MattPayne.org or (402) 208-8787
- Slides:
  - Available online at http://MattPayne.org/ssh
  - RSS Feed for updates:
    - http://www.mattpayne.org/blog/category/programming/ia/ssh/feed
  - License
    - http://creativecommons.org/licenses/by-sa/2.5/

# Outcomes & Agenda

- SSH knowledge you can put to work that same day:
- (0) SSH Basics
- (1) Does your network allow SSH tunneling to violate your firewall policy? web content filtering policy? VPN policy?
- (2) Use SSH to create two factor authentication and improve logging
- (3) Use OpenSSH configuration options to narrow the use of SSH's features to specific use cases
- (4) Lower the risk of MiTM attacks. (5) Use SSH as network duct tape.

# SSH Basics

- SSH provides:
  - Terminal services (putty, ssh, etc)
  - Remote command execution
    - ssh server “tar -czpf -” | tar xzpf -
      - http://tinyurl.com/yztu4m
  - File transfer services (scp, sftp)
    - Emacs tramp builds on this & linux has a fuse.sf.net based ssh filesystem…
  - Port forwarding -- aka tunneling
    - Local (TCP listens on local box) connects to remote
    - Remote (TCP listens on remote box) connects to local
    - Dynamic (TCP listens on local box) connects to changing remote endpoints acting as a SOCKS proxy…
    - There are many handouts on using VNC and SSH tunnels…..

# X11 (X.org) windows forwarding

- Want to run a X gui remotely (SMIT on AIX whatever)…
- ssh -X user@otherbox
- Now $DISPLAY is not :0.0 it’s :0:10 and running xeyes (or other gui) opens on the computer that ran ssh -X
- May have to run xauth (YMMV)

# Handy Authentication!

- Password Based authentication
- Key pair (public key, private key)
  - SSH access is granted to any account where the public key is in authorized_keys and the ssh client has access to the corresponding private key.
  - Private keys may have pass phrases
    - Two factor authentication!
    - We’ll see how to avoid carpal tunnel with ssh-agent
- It’s possible to connect to many different authentication mechanisms -- single signon can be done… Should it?

# Handy Uses

- Beyond terminals and file transfers there is….
  - Using X Windows (X11, kde, gnome) across the network
  - Adding encryption to network services: POP, SMTP, CVS, SVN, NFS, samba, printing, rsync, etc
    - Recall that the xinetd/inetd model is for the  network service to read from stdin & write to stdout then xinetd/inetd does the TCP stuff…

# Remote Commands

- ssh user@server “ls -lt”
  - # What’s in the $HOME directory?
- ssh user@server “cat /etc/passwd” | grep -I steve | tee steves.txt | wc -l
- Accounting? Does remote command execution show up via the output of “last”? TODO: Where is it logged by default in the ubuntu being used this semester?

# SSH Litmus Testing

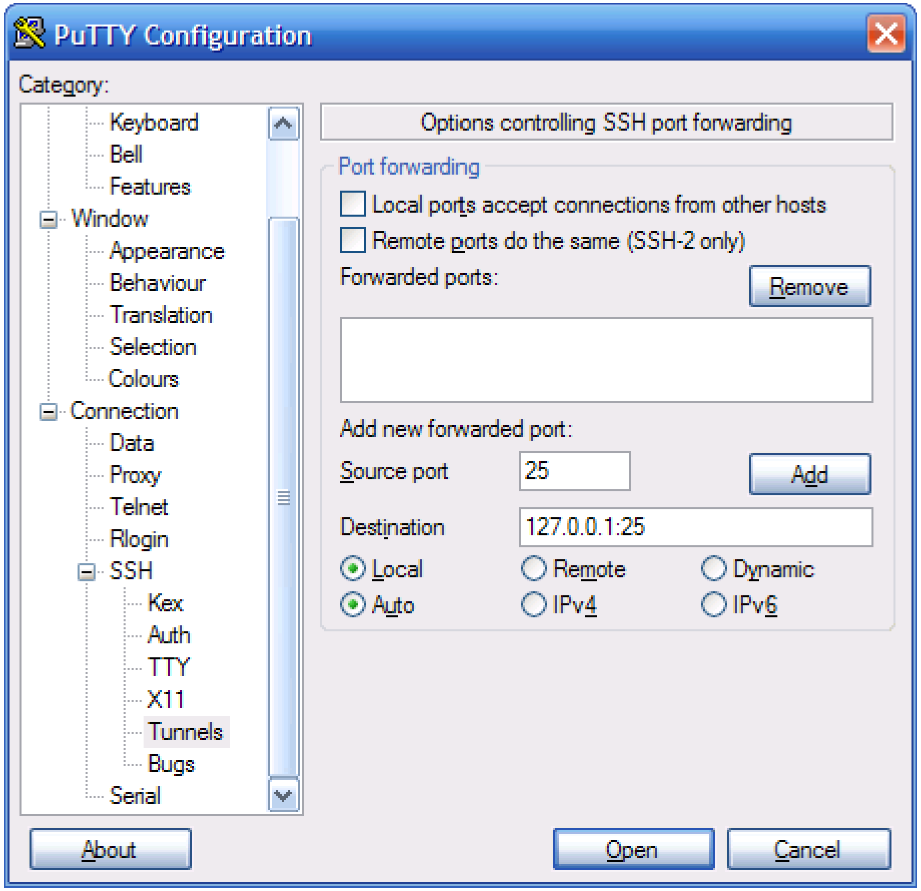
- Does your network allow SSH tunneling to violate your firewall policy?
- Web content filtering policy?
- VPN policy?
  - Try it with putty!
  - But remember Randal Schwartz first!
- Example: Suppose your network only allows outbound port 25 (SMTP) connections to mail.corporate.com

# Local Tunnels

- Can renumber ports -- connect localhost:80 to somebox.com:8080
- Suppose an ISP does not allow you to connect to anyone’s port 25 but their SMTP’s server’s port 25….
- “The internet treats censorship as a defect and routes around it."  -- John Gilmore
- ssh user@somebox.com -L 25:localhost:25
  - Now email clients (MUAs) may connect to localhost’s port 25 which is not prevented by the ISP router ACLs.
  - The ssh client accepts the port 25 connection, forwards the data to the ssh server (sshd; d is for daemon) where a connection is made to localhost:25 to forward the data.
    - Sshd’s localhost is somebox.com -- outside of the ISP’s router’s ACLs’ control.

# sudo ssh -L 25:127.0.0.1:25 account@somebox.com

- On windows with putty this looks like:
- -L is for local
- The TCP listen is done on the local box
  - Where the client runs



PuTTY Configuration

Options controlling SSH port forwarding

Port forwarding

□ Local ports accept connections from other hosts

□ Remote ports do the same (SSH-2 only)

Forwarded ports:

Add new forwarded port:

Source port: 25

Destination: 127.0.0.1:25

● Local ○ Remote ○ Dynamic

● Auto ○ IPv4 ○ IPv6

# Remote Tunnels

- A database application connects to mySQL on localhost:3306.  You want to move the mySQL server off the application box without changing the application…
- Database server boxes connect to provide the service:
  - ssh user@applicationbox -R 3306:localhost:3306
    - Many database servers can take turns providing the service…

# Collaborating…

- You’re asked to help people on a UNIX box behind a NAT.   They can ssh to the Internet but boxes on the Internet cannot login to the box behind the NAT…
- Ask your customer to:
  - ssh guestuser@some.internetbox.com -R 2000:localhost:22
  - kibitz youraccount  # part of expect.nist.gov
  - ssh localhost -p 2000 -l customerlogin

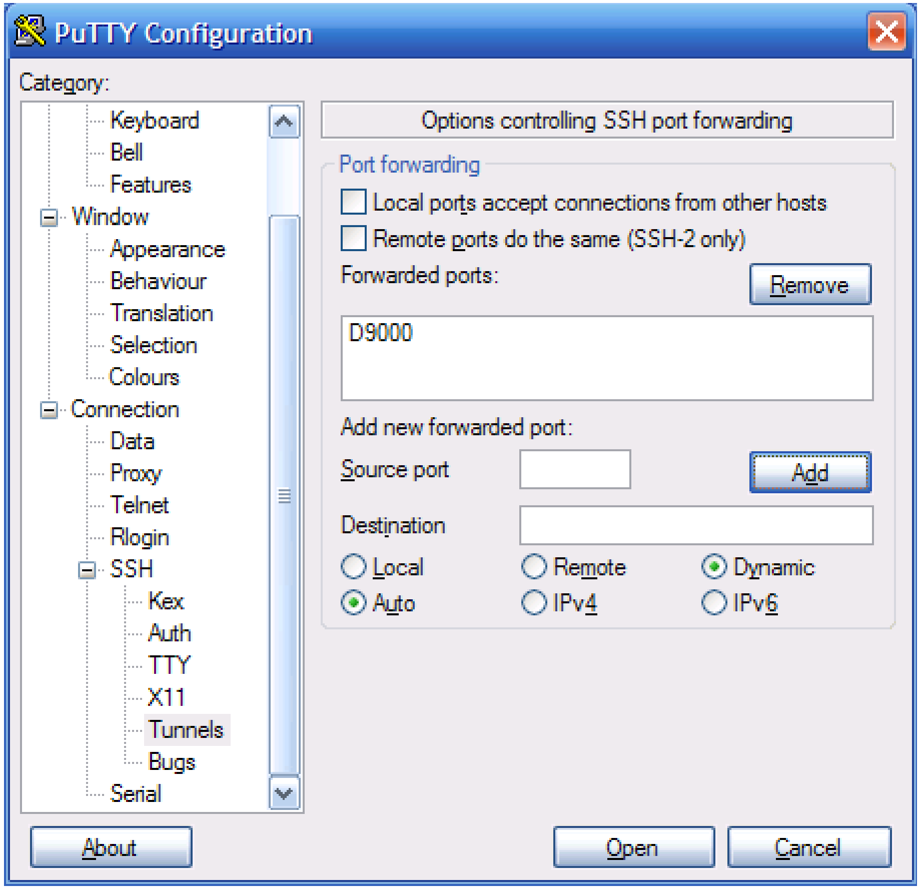
# Dynamic Port Forwarding…

- Web browsers and other programs (e.g. some IM clients) are SOCKS aware.
- ssh -D 9090 user@server.com
- Now localhost:9090 acts as a SOCKS proxy.
  - Browser (once configured) connects to localhost:9090
  - Request is passed encrypted via port 22 to sshd
  - sshd makes connection (e.g. to TheOnion.com)
- Older articles will talk about local tunnels to Squid-cache.org proxies.  This works too….

# Dynamic Port Forwarding with Putty

- First start putty with a dynamic tunnel
- Second configure your web browser to be a SOCKS client
- Third surf with:
  - “privacy”
  - Access to your Intranet
    - DNS lookups happen on the box running ssh server (sshd)

# Putty Dynamic Tunnels



PuTTY Configuration

Options controlling SSH port forwarding

Port forwarding

☐ Local ports accept connections from other hosts

☐ Remote ports do the same (SSH-2 only)

Forwarded ports:

D9000

Add new forwarded port:

Source port

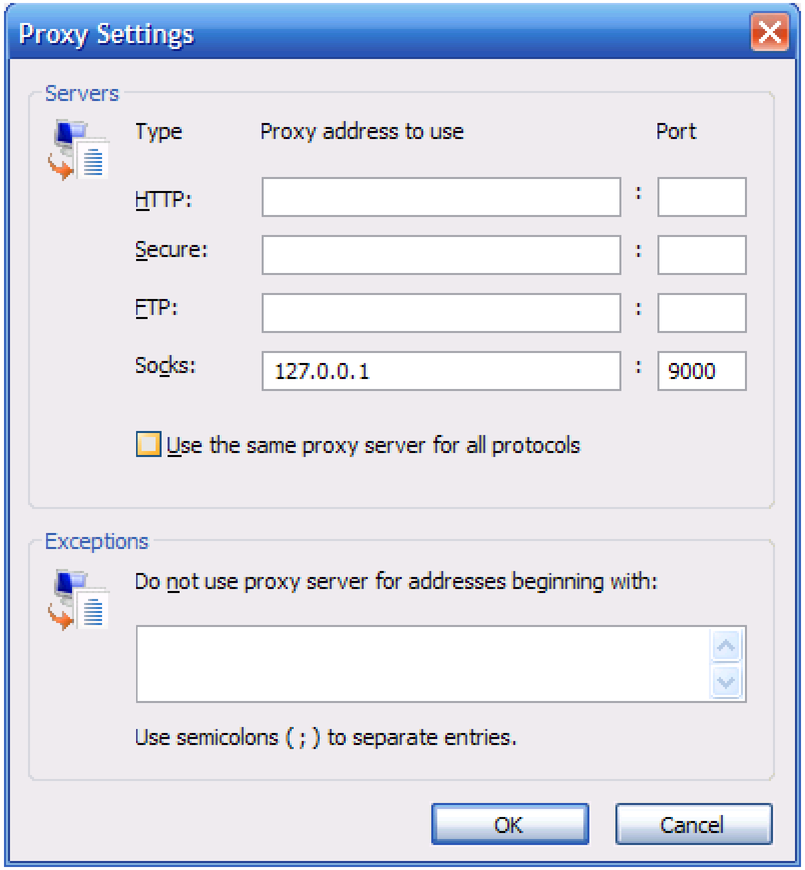
Destination

○ Local ○ Remote ● Dynamic

● Auto ○ IPv4 ○ IPv6

# IE as a SOCKS client

- IE Tools Menu
  - Internet Options
    - Connections Tab
      - LAN Settings Button
        - » Advanced Button



Proxy Settings

Servers

| Type | Proxy address to use | Port |
|---|---|---|
| HTTP: | | |
| Secure: | | |
| FTP: | | |
| Socks: | 127.0.0.1 | 9000 |

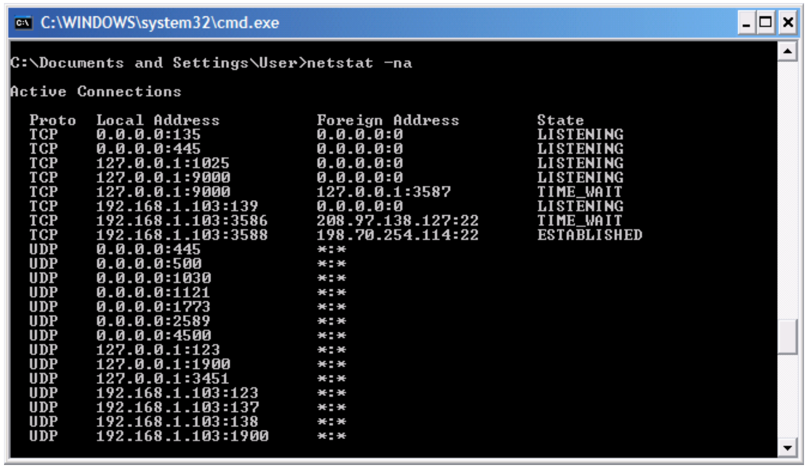
□ Use the same proxy server for all protocols

Exceptions

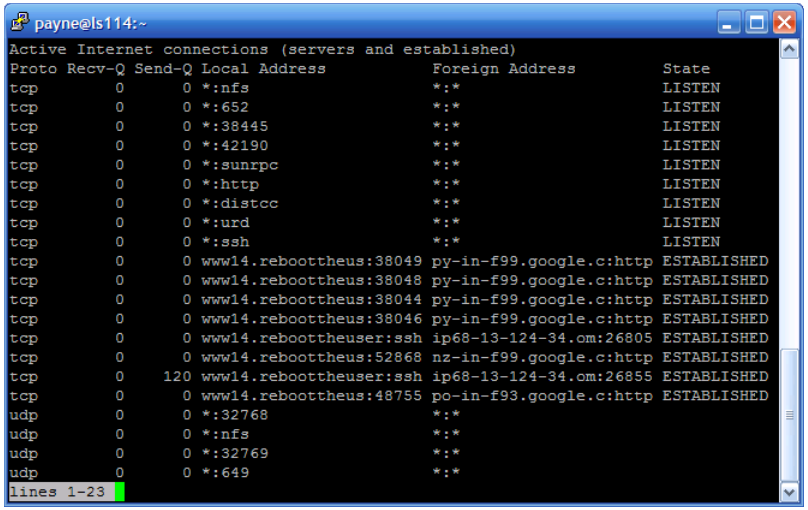
Do not use proxy server for addresses beginning with:

Use semicolons ( ; ) to separate entries.

# Local and Remote

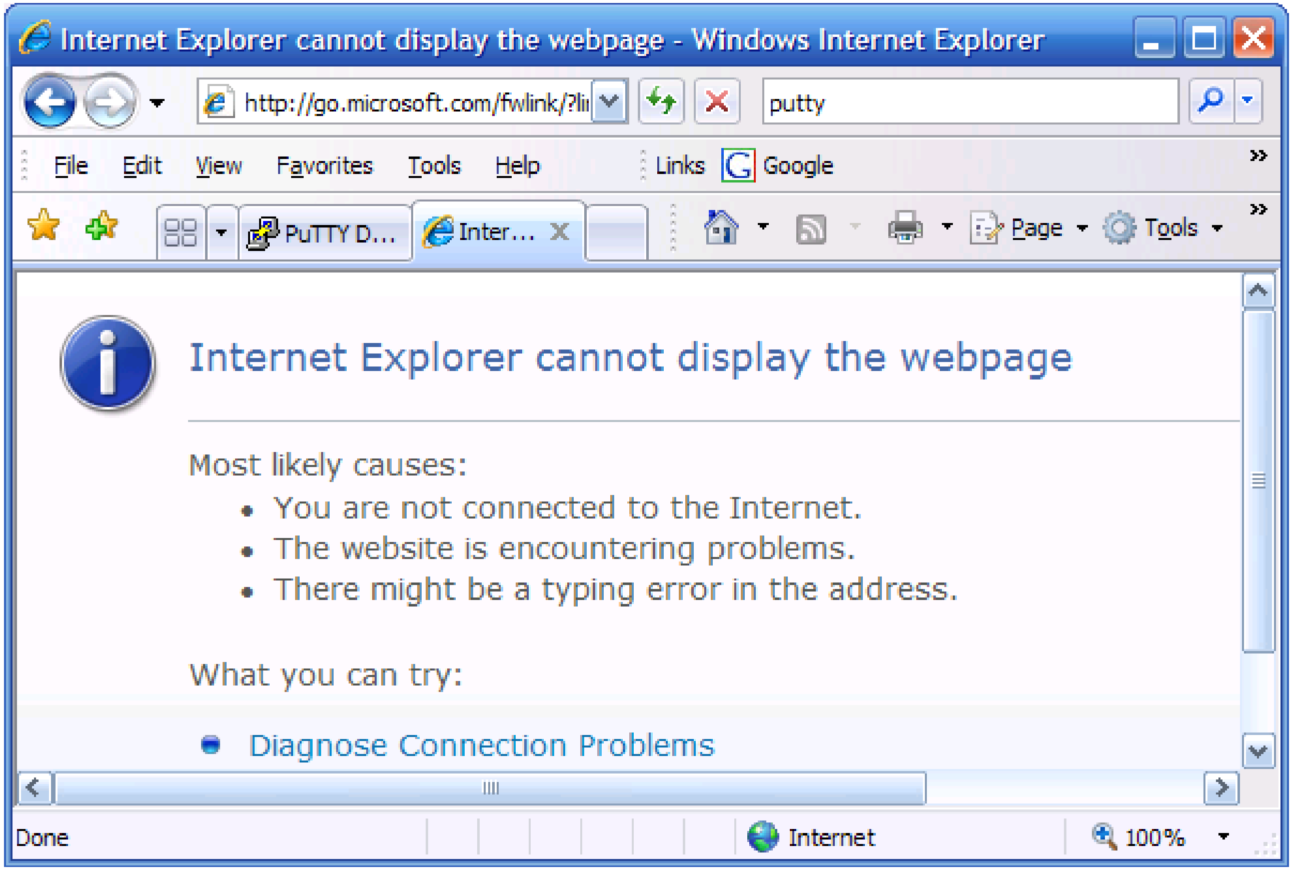


```
C:\Documents and Settings\User>netstat -na

Active Connections

  Proto  Local Address          Foreign Address        State
  TCP    0.0.0.0:135            0.0.0.0:0              LISTENING
  TCP    0.0.0.0:445            0.0.0.0:0              LISTENING
  TCP    127.0.0.1:1025         0.0.0.0:0              LISTENING
  TCP    127.0.0.1:9000         0.0.0.0:0              LISTENING
  TCP    127.0.0.1:9000         127.0.0.1:3587         TIME_WAIT
  TCP    192.168.1.103:139      0.0.0.0:0              LISTENING
  TCP    192.168.1.103:3586     208.97.138.127:22      TIME_WAIT
  TCP    192.168.1.103:3588     198.70.254.114:22      ESTABLISHED
  UDP    0.0.0.0:445            *:*
  UDP    0.0.0.0:500            *:*
  UDP    0.0.0.0:1030           *:*
  UDP    0.0.0.0:1121           *:*
  UDP    0.0.0.0:1773           *:*
  UDP    0.0.0.0:2589           *:*
  UDP    0.0.0.0:4500           *:*
  UDP    127.0.0.1:123          *:*
  UDP    127.0.0.1:1900         *:*
  UDP    127.0.0.1:3451         *:*
  UDP    192.168.1.103:123      *:*
  UDP    192.168.1.103:137      *:*
  UDP    192.168.1.103:138      *:*
  UDP    192.168.1.103:1900     *:*
```



```
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 *:nfs                   *:*                     LISTEN
tcp        0      0 *:652                   *:*                     LISTEN
tcp        0      0 *:38445                 *:*                     LISTEN
tcp        0      0 *:42190                 *:*                     LISTEN
tcp        0      0 *:sunrpc                *:*                     LISTEN
tcp        0      0 *:http                  *:*                     LISTEN
tcp        0      0 *:distcc                *:*                     LISTEN
tcp        0      0 *:urd                   *:*                     LISTEN
tcp        0      0 *:ssh                   *:*                     LISTEN
tcp        0      0 www14.reboottheus:38049 py-in-f99.google.c:http ESTABLISHED
tcp        0      0 www14.reboottheus:38048 py-in-f99.google.c:http ESTABLISHED
tcp        0      0 www14.reboottheus:38044 py-in-f99.google.c:http ESTABLISHED
tcp        0      0 www14.reboottheus:38046 py-in-f99.google.c:http ESTABLISHED
tcp        0      0 www14.reboottheuser:ssh ip68-13-124-34.om:26805 ESTABLISHED
tcp        0      0 www14.reboottheus:52868 nz-in-f99.google.c:http ESTABLISHED
tcp        0    120 www14.reboottheuser:ssh ip68-13-124-34.om:26855 ESTABLISHED
tcp        0      0 www14.reboottheus:48755 po-in-f93.google.c:http ESTABLISHED
udp        0      0 *:32768                 *:*
udp        0      0 *:nfs                   *:*
udp        0      0 *:32769                 *:*
udp        0      0 *:649                   *:*
lines 1-23
```

# When the tunnel is gone..



Internet Explorer cannot display the webpage - Windows Internet Explorer
http://go.microsoft.com/fwlink/?li
putty
File
Edit
View
Favorites
Tools
Help
Links
Google
PuTTY D...
Inter...
Page
Tools
Done
Internet
100%

Internet Explorer cannot display the webpage

Most likely causes:

- You are not connected to the Internet.
- The website is encountering problems.
- There might be a typing error in the address.

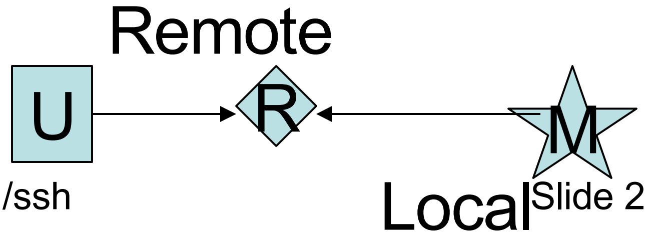
What you can try:

- Diagnose Connection Problems

# Meet in the middle tunnels

- U$ ssh -R2222:127.0.0.1:22 payne@R
- M $ ssh 192.168.0.3 -L 22:localhost:2222
- Privileged ports can only be forwarded by root.
- M $ sudo ssh 192.168.0.3 -L 22:localhost:2222
- Password:
- root@192.168.0.3's password:
- M $ sudo ssh payne@192.168.0.3 -L 22:localhost:2222
- payne@192.168.0.3's password:
- Last login: Wed Nov 29 01:49:18 2006 from 192.168.0.4
- [payne@R ~]$

- M$ ssh localhost
- Linux payne 2.6.15-23-386 #1 PREEMPT Tue May 23 13:49:40 UTC 2006 i686 GNU/Linux
- U$
- REFERENCE: portforward.com



# SSH for Two Factor Authentication

# PK auth -- 1st Time

| Step | Client | Server |
|---|---|---|
| 1 | ssh-keygen -t rsa | |
| 2 | Copy ~/.ssh/id_rsa.pub to server:/tmp | Append /tmp/id_rsa.pub to ~/.ssh/authorized_keys on server.<br>chmod 600 authorized_keys on server. |
| 3 | ssh server | You’re connected after entering private key’s passphrase (which may be blank) |

# PK & Password Auth

- Both public key and password authentication may be active!
- Changing account’s password does not invalidate the keys in ~/.ssh/authorized_keys

# SSH for Improved Logging

# authorized_keys eg:

- Examples (from man 8 sshd)

1. 1024 33 12121...312314325 ylo@foo.bar
2. from="*.niksula.hut.fi,!pc.niksula.hut.fi" 1024 35 23...2334 ylo@niksula
3. command="dump /home",no-pty,no-port-forwarding 1024 33 23…2323 backup.hut.fi
4. permitopen="10.2.1.55:80",permitopen=" 10.2.1.56:25" 1024 33 23...2323

# Example authorized_keys

- permitopen="ca.ist.unomaha.edu:22" ssh-rsa
  AAAAB3NzaC1yc2EAAAABIwAAAQEAyltw4JJQcGr
  +xReTnpELRuD9SHpNHK3EAoMUoO+GFgWgwHIi3
  QewGCaVlvjGq04bGuVPiHxbD/8c83TNWqPQ5ehfj0
  aw2L5b05/EUdHzVd9DKWxeIZB6psmblefqmJ6AGv
  +AuzWxhyUYoMGg8GTIVAmKOXAlZ+XL2Y/oefjses
  L9d5fI+rJoT5YCDpVG81EDP5HiMMkVqaAium+cfgwl
  3sFMdvlvZxuNdBZeC8FY32q98UwfeUXfxDI9z6xOja
  JC5hd2tw70j0x3HJdRFbQEPJdnZZfT/0GvMcOgh5D
  54SQiaFE2FCwPDN0qFMqGO79jg4cZ6MPDyqvFQ
  256UpGcbw== payne@matt-paynes-computer.local

# Using find…

- No surprise authorized_keys files
- Wouldn’t it be nice if PKs had expiration dates!
- Script to coordinate last (and other logs) and authorized_keys files
  - User goes inactive for X days and their public keys are set to only execute a cat /etc/contact-security command….

# Narrowing SSH use cases

# Lower the risk of MiTM Attacks

# SSH as Network Duct Tape

# SSH Basics

# Limiting & commenting PKs

- http://tinyurl.com/yddkk5 says:
- Each line of authorized_keys contains up to three items in order, some optional and some required:
  - A set of options (optional, surprise, surprise).
  - The public key (required).
  - A descriptive comment (optional). This can be any text, such as "Bob's public key"
  - Comments may also start with #
- Options include (cf “man 8 sshd”):
  - permitopen
  - command
  - from
  - environment
  - no-port-forwarding

# ssh-agent: avoiding carpel tunnel…

- OS X: sshkeychain.org
  - matt-paynes-computer:~ payne$ env|grep SSH
  - SSH_AUTH_SOCK=/tmp/501/SSHKeychain.sock et
  - matt-paynes-computer:~ payne$
- Ubuntu & other unix: ssh-agent
  - ssh-agent bash # Start a bash w/ env vars
  - ssh-add # Add identity to agent…

# Example….

```
• payne@payne:~$ ls .ssh
• authorized_keys  id_rsa  id_rsa.pub  known_hosts
• payne@payne:~$ cat .ssh/id_rsa.pub |ssh
  ca.ist.UNOmaha.edu 'cat >> .ssh/authorized_keys'
• payne@ca.ist.unomaha.edu's password:
• payne@payne:~$ ssh ca.ist.UNOmaha.edu
• Enter passphrase for key '/home/payne/.ssh/id_rsa':
• Last login: Wed Nov 29 14:14:08 2006 from
  rp614v3.ist.unomaha.edu
• [payne@cist4370 ~]$
```

# Example cont….

```
•   payne@payne:~$ ps
•     PID TTY          TIME CMD
•    3036 pts/3    00:00:00 bash
•    3060 pts/3    00:00:00 ps
•   payne@payne:~$ ssh-agent bash
•   payne@payne:~$ ps
•     PID TTY          TIME CMD
•    3036 pts/3    00:00:00 bash
•    3063 pts/3    00:00:00 bash
•    3083 pts/3    00:00:00 ps
•   payne@payne:~$ ssh-add
•   Enter passphrase for /home/payne/.ssh/id_rsa:
•   Identity added: /home/payne/.ssh/id_rsa (/home/payne/.ssh/id_rsa)
•   payne@payne:~$ ssh ca.ist.UNOmaha.edu
•   Last login: Wed Nov 29 14:20:24 2006 from rp614v3.ist.unomaha.edu
•   [payne@cist4370 ~]$
```

# Avoiding MITM attacks

- Most PK schemes (SSH, SSL, PGP, etc) are open to Man in the Middle Attacks
  - http://tinyurl.com/pbkd9
- A known_hosts file can be kept at the machine level and the account level
- Holds key ids for sshds connected to

# Tweaking OpenSSH configs

- sshd_config (typically in /etc/ssh)
  - Out of the box: PermitRootLogin yes
    - Should be no!  Why?
  - Out of the box: Tunneling is on!  man sshd_config says:
    - AllowTcpForwarding
      - Specifies whether TCP forwarding is permitted.  The default is ``yes''.  Note that disabling TCP forwarding does not improve  security unless users are also denied shell access, as they can always install their own forwarders.
  - Should AllowTcpForwarding and X11Forwarding really be on out of the box?  There is a way to permit only certain users to tunnel…

# Permitting only one tunnel

- root@payne:/home/payne/.ssh#
  - chown root.root authorized_keys
- root@payne:/home/payne/.ssh#
  - chmod a+r authorized_keys
- root@payne:/home/payne/.ssh#
  - grep permit authorized_keys
- permitopen="ca.ist.unomaha.edu:22" ssh-rsa AAAAB3NzaC1yc2EAAAABIwAAAQEAyltw4JJQcGr+ **Truncated**

# But, password PasswordAuthentication no??

- Needed to limit tunnels to special users….
- Will users put up with this?
- http://www.gentoo.org/proj/en/keychain/
-  Pagent.exe — SSH key agent http://tinyurl.com/gpj8c
- OS X sshkeychain.org

# Turning off tunnels at the client

- In /etc/ssh_config set to no
  - DynamicForward
  - LocalForward
  - RemoteForward
- Putty and other clients?
- Microsoft’s Port Reporter?

# Auth.log out of the box

- Nov 29 10:46:27 payne sshd[3458]: Accepted publickey for payne from 127.0.0.1 port 44503 ssh2
- Nov 29 10:46:27 payne sshd[3460]: (pam_unix) session opened for user payne by (uid=0)
- Tweak:

```
– root@payne:/etc/ssh# grep LogLevel sshd_config
– #LogLevel INFO
– LogLevel VERBOSE
– root@payne:/etc/ssh# /etc/init.d/ssh restart
–  * Restarting OpenBSD Secure Shell server...
–    ...done.
– root@payne:/etc/ssh#
```

# Auth.log after tweak

- Nov 29 10:48:34 payne sshd[3549]: Failed none for payne from 127.0.0.1 port 44504 ssh2
- Nov 29 10:48:34 payne sshd[3549]: Found matching RSA key: 8b:48:99:64:c4:04:67:ed:6c:0f:b1:63:41:5f:41:1b
- Nov 29 10:48:34 payne sshd[3549]: Found matching RSA key: 8b:48:99:64:c4:04:67:ed:6c:0f:b1:63:41:5f:41:1b
- Nov 29 10:48:34 payne sshd[3549]: Accepted publickey for payne from 127.0.0.1 port 44504 ssh2
- Nov 29 10:48:34 payne sshd[3553]: (pam_unix) session opened for user payne by (uid=0)

# Matching auth.log to authorized_keys

```
payne@payne:~$ while read pubkey
> do
>     echo $pubkey > /tmp/pk
>     ssh-keygen -l -f /tmp/pk
> done < .ssh/authorized_keys
2048 8b:48:99:64:c4:04:67:ed:6c:0f:b1:63:41:5f:41:1b /tmp/pk
1024 b4:a5:7b:62:83:bb:56:4a:49:18:eb:1e:c3:18:15:68 /tmp/pk
2048 6a:95:2b:9c:16:02:d1:33:d2:2d:12:15:a4:0b:1d:94 /tmp/pk
2048 fd:ac:c4:8f:bf:b6:f4:82:a0:8c:9e:90:35:d8:d2:3e /tmp/pk
payne@payne:~$
```

- Thanks google and http://tinyurl.com/yh2875

# Mantra: Implementation & Key Management

- Implementation story
  - Buffer Overflow
    - P.156 o f ORA.com’s Network Security Assessment by by Chris McNab
    - Using NVD.gov to track software versions…
  - Mantissa attack
- Key Management story:
  - Mystery lab scenario from 11/21/2006
  - Mitigation -- crontab that deletes authorized_keys if no login within X days? Or crontab that makes security administrators aware…

# Check these out…

- “Using DNS to Securely Publish Secure Shell (SSH) Key Fingerprints”
  - http://www.ietf.org/rfc/rfc4255.txt © 2006
- Refs
  - rSync and SSH
    - http://www.linuxtoday.com/storage/2006082100526OSHLSV
  - GDB and SSH Tunneling
    - http://www.cucy.net/lacp/archives/000024.html
  - http://souptonuts.sourceforge.net/sshtips.htm
  - http://en.wikipedia.org/wiki/Corkscrew_%28program%29
  - http://proxytunnel.sourceforge.net/users.php

# Squid for Privacy

- COTSE.net

Cotse.Net
E-mail · Web Proxy · Web Hosting · Usenet & More
"..the Internet's Full Service Privacy Website,
Your Shield from the Internet."

  - Church of the Swimming Elephant
    - Proxies and more for $6/month

- Many people just setup Squid, connect to it with a SSH tunnel and stop there…
  - squid-cache.org
- Or use a dynamic tunnel….

# 2006 Articles on SSH

- Tunnelling with SSH -- Oct 2006
  - http://www-128.ibm.com/developerworks/aix/library/au-tunnelingssh/
- **Mitigating the Security Risks of SSH -- Aug 2006**
  - http://www.informit.com/articles/article.asp?p=602977&rl=1
- **SSH Issues: Does Installing SSH Enable More Exploits Than it Solves? -- May 2006**
  - http://www.samspublishing.com/articles/article.asp?p=471099&rl=1
- SSH Tunnels: Bypass (Almost) Any Firewall --- Aug 2006
  - http://polishlinux.com/apps/ssh-tunneling-to-bypass-corporate-firewa

# Misc Refs

- Libraries
  - http://www.cs.auckland.ac.nz/%7Epgut001/
  - http://www.lysator.liu.se/%7Enisse/lsh/
  - http://www.jcraft.com/jsch/
- MAC?
  - http://xanana.ucsc.edu/~wgscott/xtal/wiki/in

# Questions?

- Speaker:
  - Matt Payne, CISSP
  - Contact: Payne@MattPayne.org or (402) 208-8787
- Slides:
  - Available online at http://MattPayne.org/ssh
  - RSS Feed for updates:
    - http://www.mattpayne.org/blog/category/programming/ia/ssh/feed
  - License
    - http://creativecommons.org/licenses/by-sa/2.5/