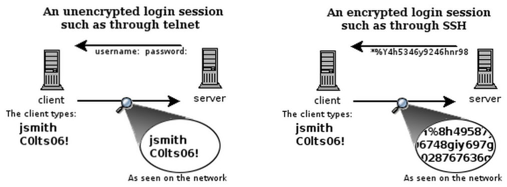
CS 35L Software Construction Lab
Week 7 – SSH

What is SSH?

- **S**ecure **Sh**ell
- Used to remotely access shell
- Successor of telnet
- Encrypted and better authenticated session



Encryption Types

- **Symmetric Key Encryption**
  - a.k.a shared/secret key
  - Key used to encrypt is the same as key used to decrypt
- **Asymmetric Key Encryption: Public/Private**
  - 2 different (but related) keys: public and private
    - Only creator knows the relation. Private key cannot be derived from public key
  - Data encrypted with public key can only be decrypted by private key and vice versa
  - Public key can be seen by anyone
  - **Never** publish private key!!!

Symmetric-key Encrption

- Same secret key used for encryption and decryption
- **Example** : Data Encryption Standard (**DES**)
- **Caesar's cipher**
  - Map the alphabet to a shifted version
    - ABCDEFGHIJKLMNOPQRSTUVWXYZ
    - DEFGHIJKLMNOPQRSTUVWXYZABC
  - Plaintext – SECRET. Ciphertext – VHFUHW
  - Key is 3 (number of shifts of the alphabet)
- **Key distribution** is a problem
  - The secret key has to be delivered in a safe way to the recipient
  - Chance of key being compromised

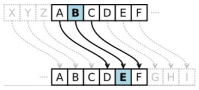


Image Source: wikipedia

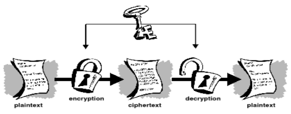


Image Source: gpgtools.org

Public-key Encryption (Asymmetric)

- Uses a pair of keys for encryption
  - **Public key** – Published and known to everyone
  - **Private key** – Secret key known only to the owner
- **Encryption**
  - Use public key to encrypt messages
  - Anyone can encrypt message, but they cannot decrypt the ciphertext
- **Decryption**
  - Use private key to decrypt messages
- **Example** : **RSA** – Rivest, Shamir & Adleman
  - Property used - **Difficulty of factoring** large integers to prime numbers
  - N = p * q (3233 = 61 * 53)
  - N is a large integer and p, q are prime numbers
  - N is part of the public key
  - https://en.wikipedia.org/wiki/RSA_(cryptosystem)

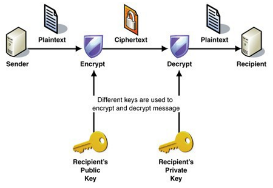


Image Source: MSDN

High-Level SSH Protocol

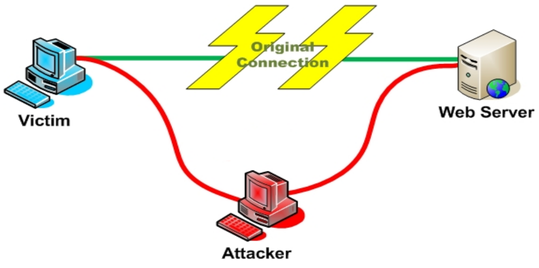
- Client ssh's to remote server
  - `$ ssh username@somehost`
  - If first time talking to server -> host validation

```
The authenticity of host 'somehost (192.168.1.1)' can't be established.
RSA key fingerprint is 90:9c:46:ab:03:1d:30:2c:5c:87:c5:c7:d9:13:5d:75.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'somehost' (RSA) to the list of known hosts.
```

  - ssh doesn't know about this host yet
  - shows hostname, IP address and fingerprint of the server's public key, so you can be sure you're talking to the correct computer
  - After accepting, public key is saved in ~/.ssh/known_hosts

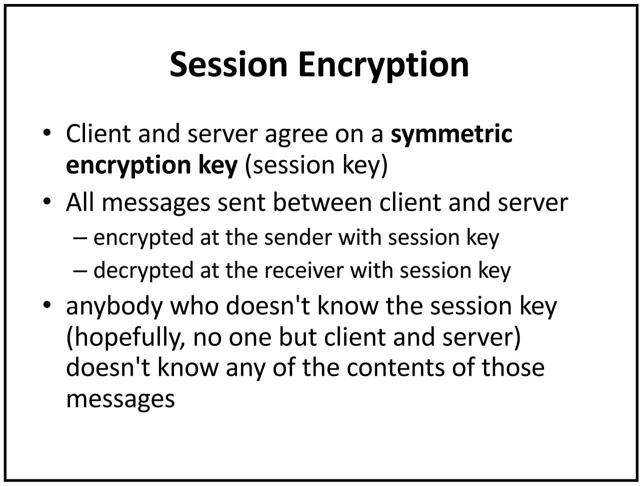
Host Validation

- Next time client connects to server
  - Check host's public key against saved public key
  - If they don't match



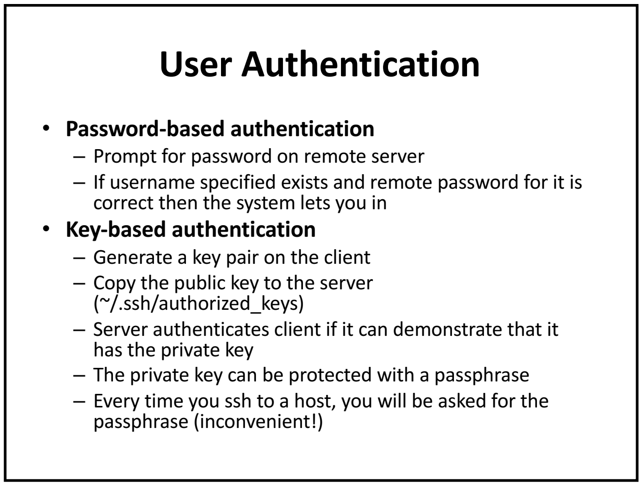
Host Validation (cont'd)

- Client asks server to prove that it is the owner of the public key using **asymmetric encryption**
  - Encrypt a message with public key
  - If server is true owner, it can decrypt the message with private key
- If everything works, host is successfully validated



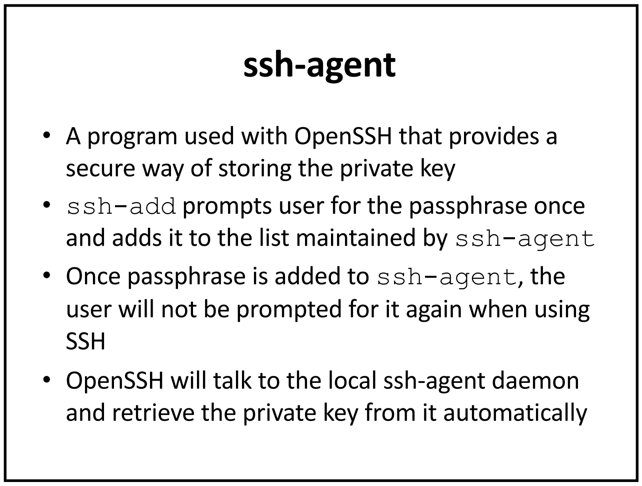
Session Encryption

- Client and server agree on a **symmetric encryption key** (session key)
- All messages sent between client and server
  - encrypted at the sender with session key
  - decrypted at the receiver with session key
- anybody who doesn't know the session key (hopefully, no one but client and server) doesn't know any of the contents of those messages



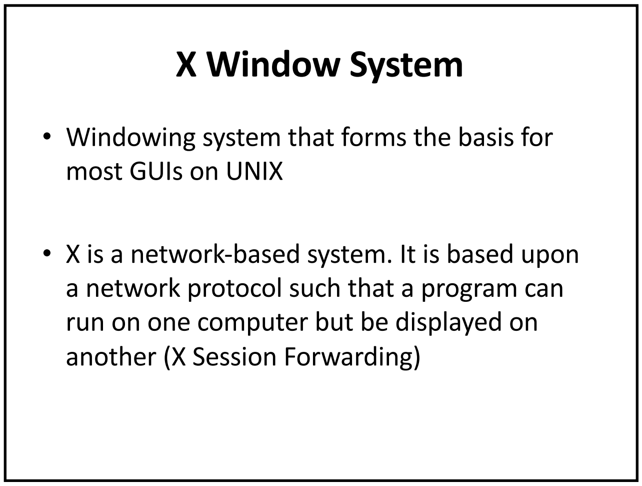
User Authentication

- **Password-based authentication**
  - Prompt for password on remote server
  - If username specified exists and remote password for it is correct then the system lets you in
- **Key-based authentication**
  - Generate a key pair on the client
  - Copy the public key to the server (~/.ssh/authorized_keys)
  - Server authenticates client if it can demonstrate that it has the private key
  - The private key can be protected with a passphrase
  - Every time you ssh to a host, you will be asked for the passphrase (inconvenient!)



ssh-agent

- A program used with OpenSSH that provides a secure way of storing the private key
- `ssh-add` prompts user for the passphrase once and adds it to the list maintained by `ssh-agent`
- Once passphrase is added to `ssh-agent`, the user will not be prompted for it again when using SSH
- OpenSSH will talk to the local ssh-agent daemon and retrieve the private key from it automatically



X Window System

- Windowing system that forms the basis for most GUIs on UNIX
- X is a network-based system. It is based upon a network protocol such that a program can run on one computer but be displayed on another (X Session Forwarding)

Lab 7

- **Securely log in to each others' computers**
  - Use ssh (OpenSSH)
- **Use key-based authentication**
  - Generate key pairs
- **Make logins convenient**
  - type your passphrase once and be able to use ssh to connect to any other host without typing any passwords or passphrases
- **Use port forwarding** to run a command on a remote host that displays on your host

Server Steps

- **Generate public and private keys**
  - $ `ssh-keygen` (by default saved to ~/.ssh/is_rsa and id_rsa.pub) – don't change the default location
- **Create an account for the client on the server**
  - $ `sudo useradd -d /home/<homedir_name> -m <username>`
  - $ `sudo passwd <username>`
- **Create .ssh directory for new user**
  - $ `cd /home/<homedir_name>`
  - $ `sudo mkdir .ssh`
- **Change ownership and permission on .ssh directory**
  - $ `sudo chown -R username .ssh`
  - $ `sudo chmod 700 .ssh`
- **Optional: disable password-based authentication**
  - `$ emacs /etc/ssh/sshd_config`
  - change PasswordAuthentication option to no

Client Steps

- **Generate public and private keys**
  - $ `ssh-keygen`
- **Copy your public key to the server for key-based authentication (~/.ssh/authorized_keys)**
  - $ `ssh-copy-id -i UserName@server_ip_addr`
- **Add private key to authentication agent (ssh-agent)**
  - $ `ssh-add`
- **SSH to server**
  - $ `ssh UserName@server_ip_addr`
  - $ `ssh -X UserName@server_ip_addr` (X11 session forwarding)
- **Run a command on the remote host**
  - $ `xterm`, $ `gedit`, $ `firefox`, etc.

How to Check IP Addresses

- $ `ifconfig`
  - configure or display the current network interface configuration information (IP address, etc.)
- $ `hostname -I`
  - gives the IP address of your machine directly
- $ `ping <ip_addr>`(**p**acket **in**ternet **g**roper)
  - Test the reachability of a host on an IP network
  - measure round-trip time for messages sent from a source to a destination computer
  - Example: $ ping 192.168.0.1, $ ping google.com