CS 35L- Software Construction Laboratory

Fall 18

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SSH - Secure Shell

Week 9

Outline

- **Introduction to Cryptography**
- **Secure Shell (SSH)**
- BeagleBone setup & team formation
- Hints for Assignment 7

Communication Over the Internet

- What type of guarantees do we want?
  - Confidentiality - Message secrecy
  - Data integrity - Message consistency
  - Authentication - Identity confirmation
  - Authorization - Specifying access rights to resources

Cryptography Terms

- Plaintext - actual message
- Ciphertext - encrypted message (unreadable gibberish)
- Encryption - converting from plaintext to ciphertext
- Decryption - converting from ciphertext to plaintext
- Secret key
  - part of the mathematical function used to encrypt\decrypt
  - Good key makes it hard to get back plaintext from ciphertext

Symmetric-key Encryption

- Same secret key used for encryption and decryption
- Example : Data Encryption Standard
- **Caesar's cipher**
  - Map the alphabet to a shifted version

    Plaintext – S E C R E T =>

    Ciphertext – V H F U H W
  - 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

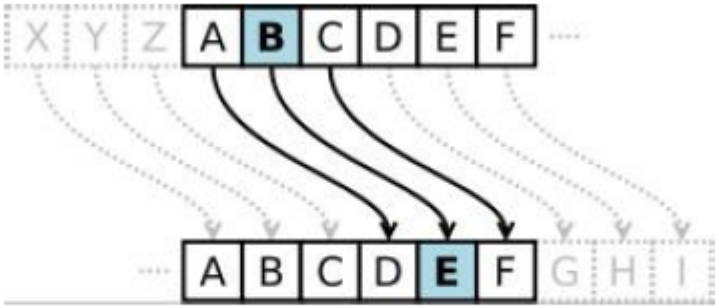


Image Source: wikipedia

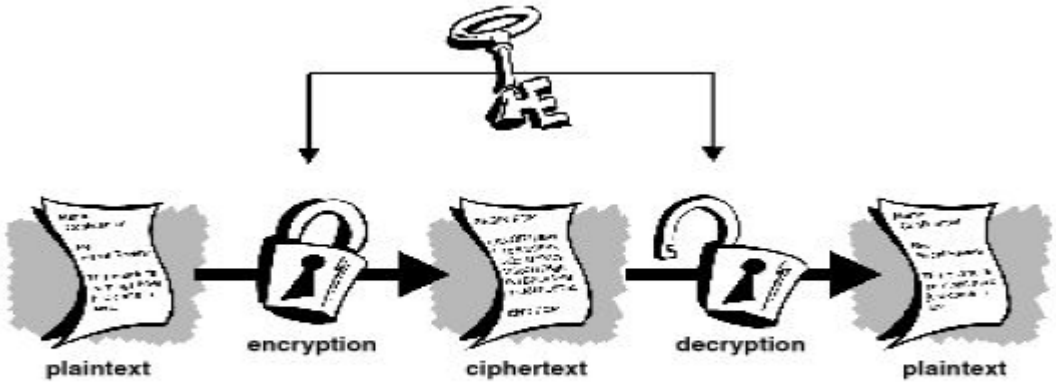


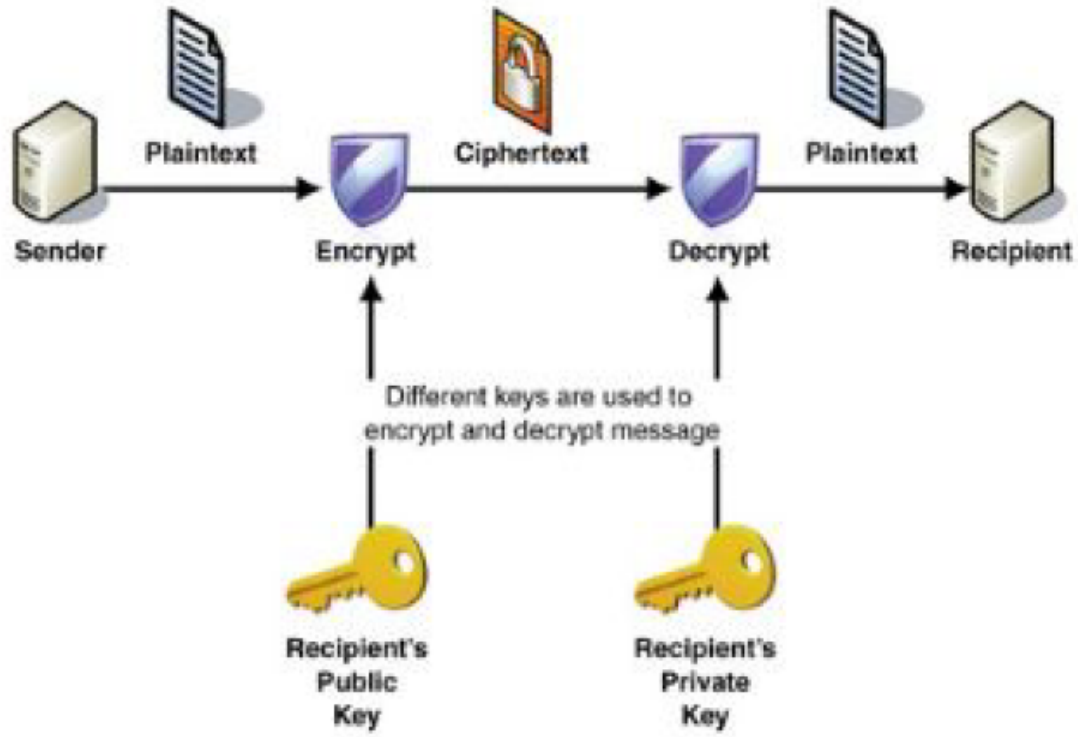
Image Source: gpgtools.org

Public-Key Encryption (Asymmetric)

- Uses a pair of keys for encryption
  - Public Key - published and well known to everyone
  - Private - 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
- In what scheme is this encryption useful?

Public-Key Encryption (Asymmetric)

- Example: RSA
  - Property used: Difficulty of factoring large integers to prime numbers
  - N= p * q
  - N is a large integer
  - p, q are prime numbers
  - N is part of the public key



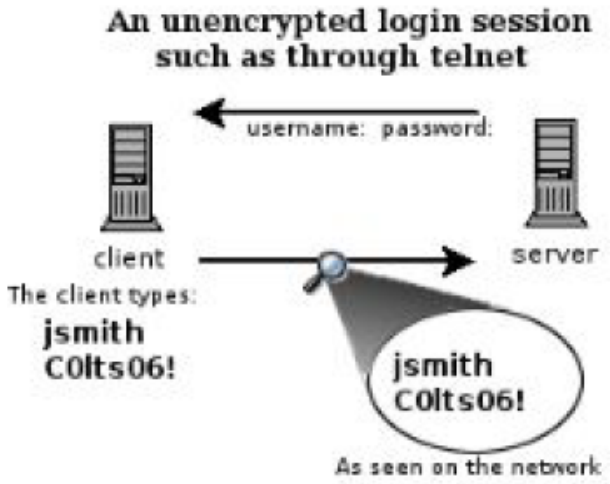
- https://en.wikipedia.org/wiki/RSA_Factoring_Challenge

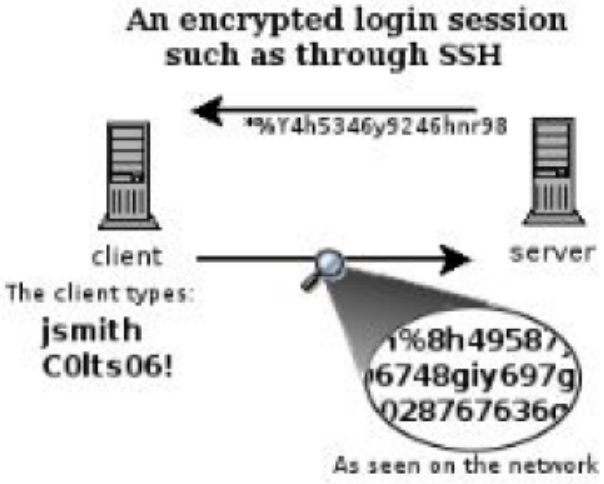
Encryption Types Comparison

- 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!!!

Secure Shell (SSH)

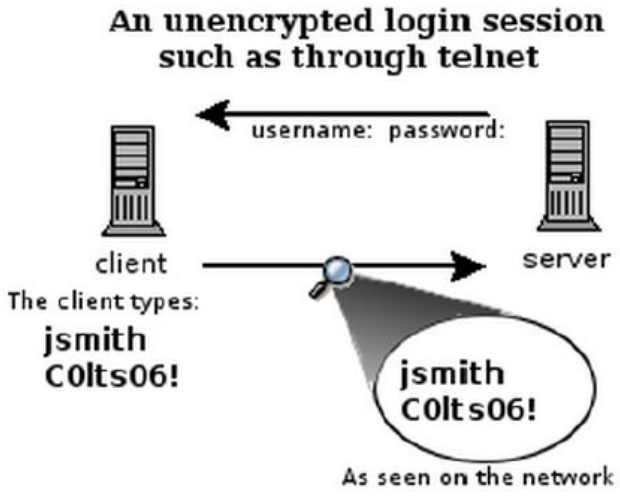
- Telnet
  - Remote access
  - Not encrypted
  - Packet sniffers can intercept sensitive information (username/password)
- SSH
  - run processes remotely
  - encrypted session
  - Session key (secret key) used for encryption during the session





What is SSH?

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



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

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

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 and retrieve the private key from it automatically

Account Administration

- Install OpenSSH (should be done on both server and client)
  - **sudo apt-get update**
  - **sudo apt-get install openssh-server**
  - **sudo apt-get install openssh-client**
- Server
  - **sudo useradd -d /home/<username> -m <UserName>**
  - **sudo passwd <username>**
  - **cd /home/<username>**
  - **sudo mkdir .ssh**
  - **sudo chown -R <username> .ssh**
  - **sudo chmod 700 .ssh**
  - **ifconfig** (this will give you the IP address of the server. Give this to your partner)
  - **ps aux | grep ssh**

Account Administration

- Client
  - Password login

    ping server_ip_addr (just to check if the server responds)

    ssh <username>@server_ip_addr
  - Password-less login

    ssh-keygen

    ssh-copy-id -i <username>@server_ip_addr

    ssh <username>@server_ip_addr (should not ask for login password)
  - Passphrase-less login
    - **ssh-add**
    - **ssh -X <username>@server_ip_addr** (should not ask for key's passphrase)
  - X session forwarding - running programs with GUI
    - **ssh -X <UserName>@server_ip_addr**
    - **xterm**
    - **firefox**

X session forwarding

- **X** is the windowing system for GUI apps on Linux
- **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
  - i.e. you want to run such apps remotely, but the GUI should show up on the local machine
- Windowing system forms the basis for most GUIs on Unix
  - **ssh -X username@ugrad.seas.ucla.edu**
  - **gedit**
  - **gimp**

Secure copy (scp)

- Based on secure shell (ssh)
- Used for transferring files between hosts in a secure way (encrypted)
- Usage similar to cp
  - **scp [source] [destination]**
- Transferring to remote host
  - **scp /home/username/doc.txt username@ugrad.seas.ucla.edu: /home/user/docs**
  - Transferring from remote host

scp username@ugrad.seas.ucla.edu:/home/user/docs/foo.txt /home/username

Assignment 8 is available

- Visit:

  http://web.cs.ucla.edu/classes/spring18/cs35L/assign/assign7.html
- Form a team of 2-3 (Preferably 2, can be in another lab)
  - Report your and your team member's UID to log.txt
- **BeagleBone setup instructions:**
  - https://piazza.com/class/jfinlsjb34f3vc?cid=282
- Follow these instructions to **reset** a used board:
  - http://wiki.seeedstudio.com/BeagleBone_Green/#update-to-latest-software

Lab 8

- Securely login 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

On your PC:

- Make sure X11 forwarding is enabled:
  - Putty: Connection -> SSH -> X11 -> “Enable X11 forwarding” should be checked
  - SSH command (Mac/Linux): -X or -Y flag
- Make sure an X11 windowing tool is installed:
  - Windows: Xming
  - Mac: XQuartz
  - (U|Li)nix: No extra software necessary!

Lab Environment Setup

- On your board:
  - Make sure you have openssh-server and openssh-client installed
  - Check: *$ dpkg --get-selections | grep openssh*

    should output:
    - openssh-server install
    - openssh-client install
  - If not:
    - *$ sudo apt-get install openssh-server*
    - *$ sudo apt-get install openssh-client*

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`

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.)
- *$ 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