A bit of crypto

CS 35L
Section 7: Week 2 - Tuesday

Spring 2020

Slides adapted from Tyler Davis

Communication Over the Internet

- What type of guarantees do we want?
  - **Confidentiality**
    - Message secrecy
  - **(Data) Integrity**
    - Message consistency
  - **Authentication**
    - Identity confirmation
  - **Also authorization**
    - Specifying access rights to resources

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)

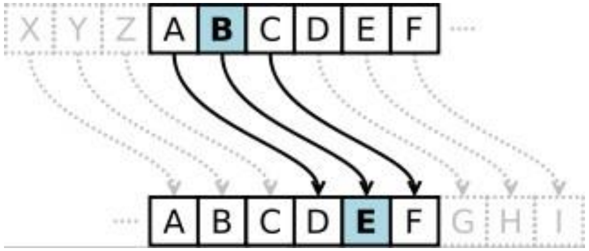


Image Source: wikipedia

- **Key distribution** is a problem
  - The secret key has to be delivered in a safe way to the recipient
  - Chance of key being compromised

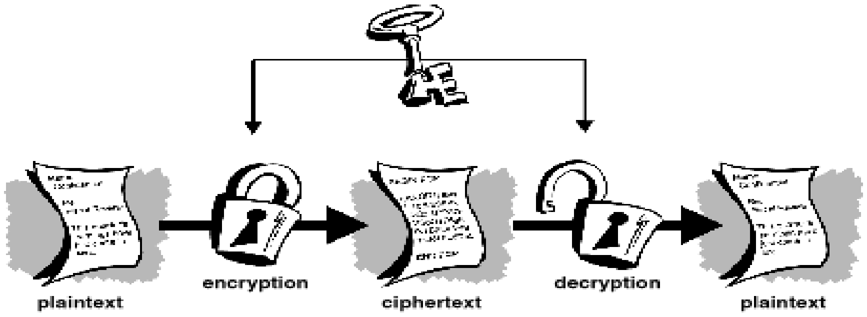
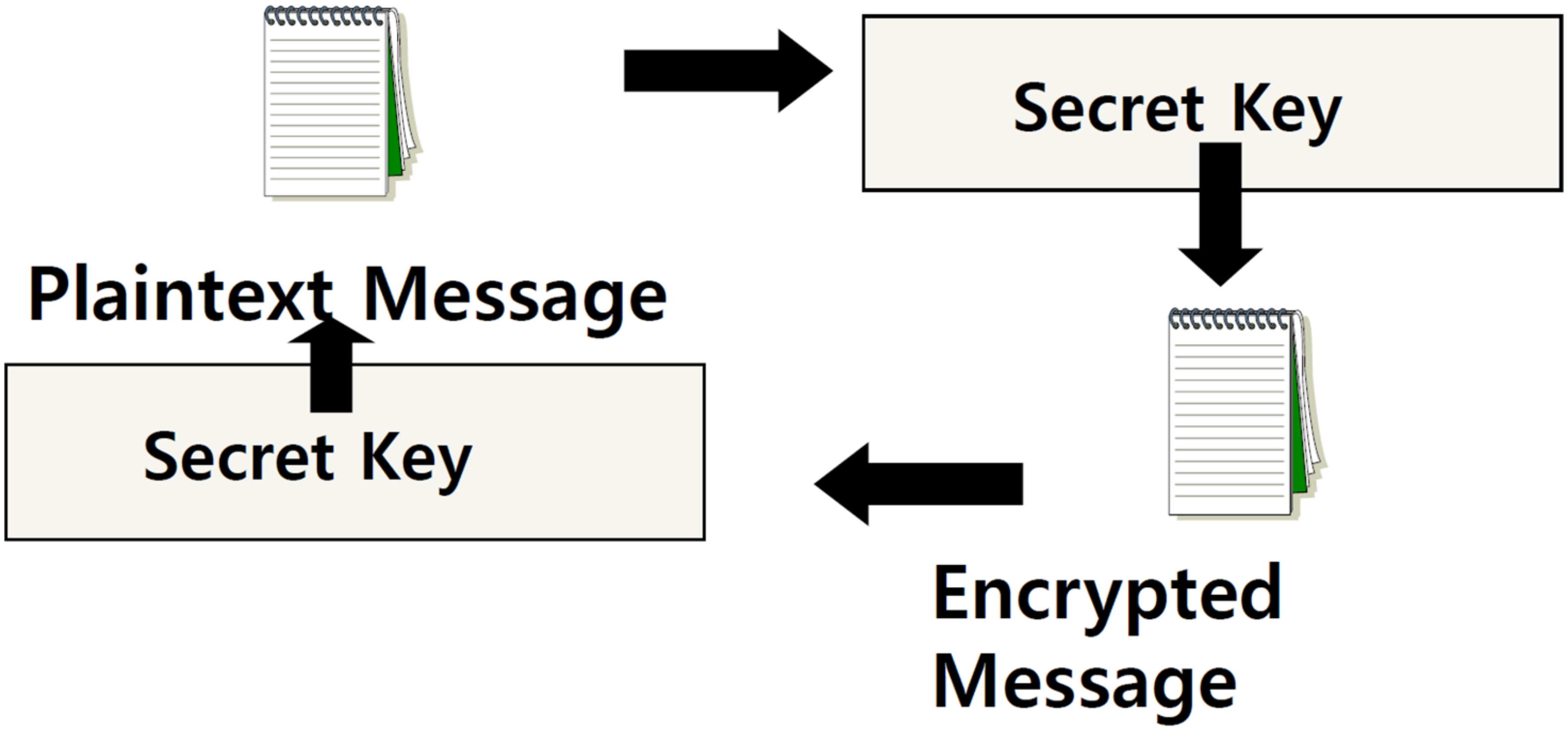


Image Source: gpgtools.org

Secret Key (symmetric) Cryptography

- A single key is used to both encrypt and decrypt a message



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

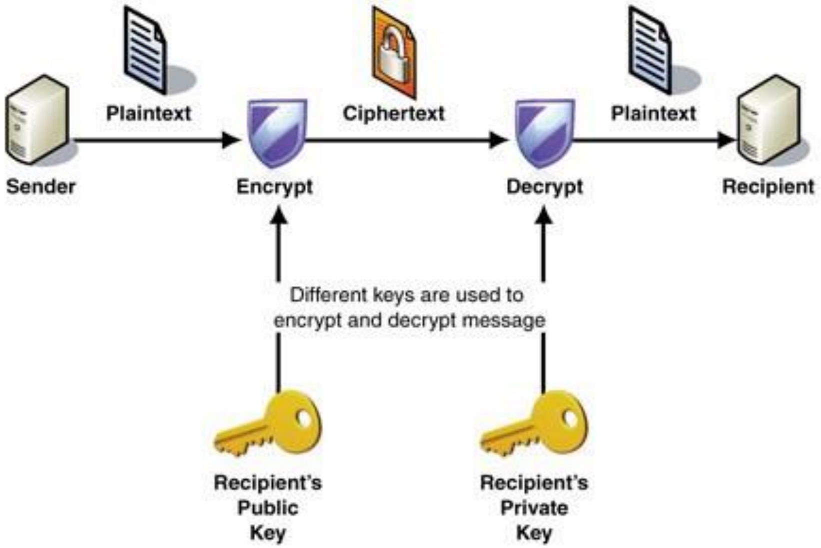
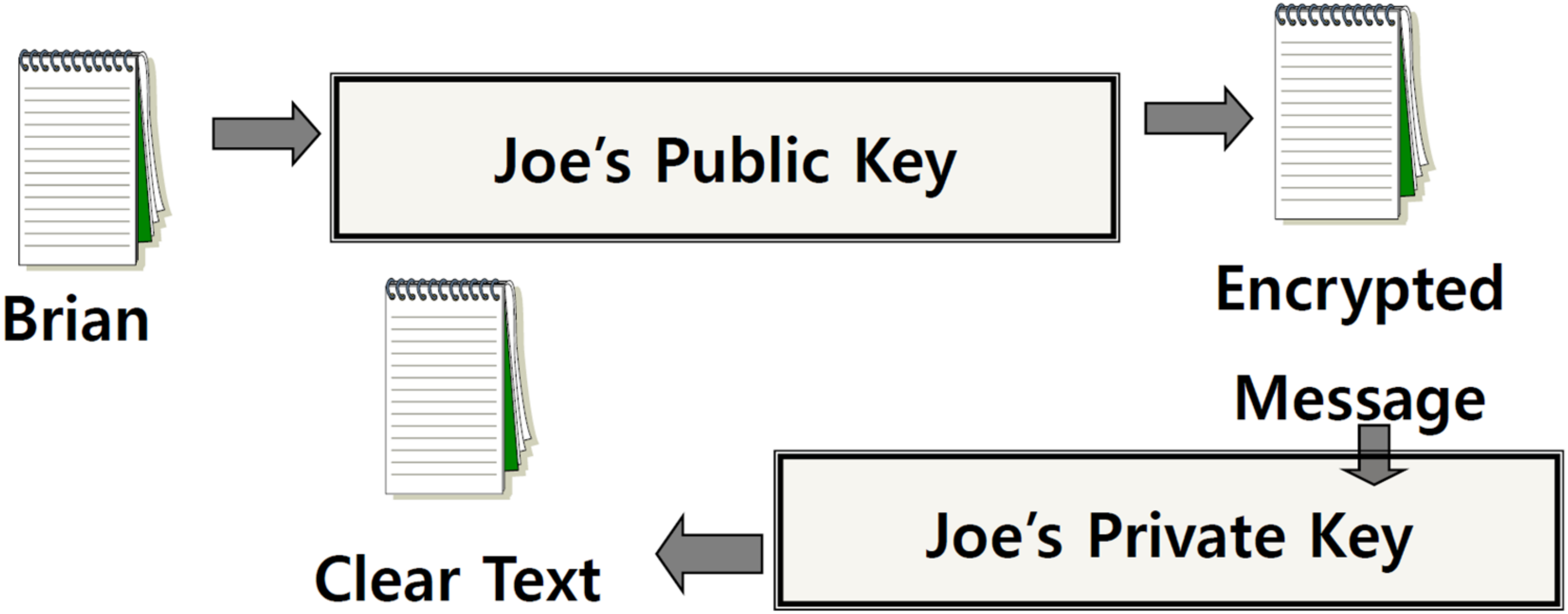


Image Source: MSDN

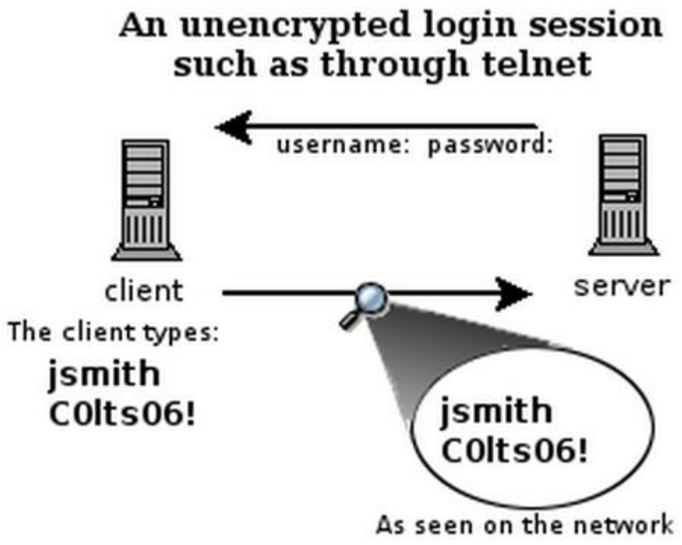
Public Key (asymmetric) Cryptography

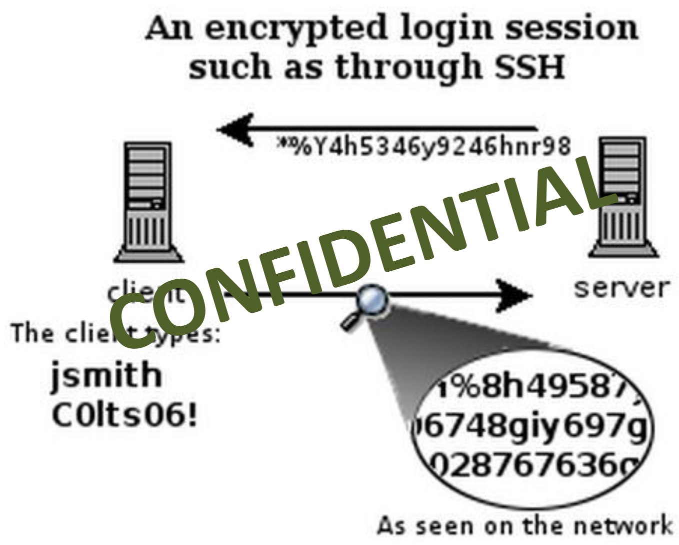
- Two keys are used: a public and a private key. If a message is encrypted with one key, it has to be decrypted with the other.



What is SSH?

- Secure Shell
- Used to remotely access shell
- Successor of telnet
- Encrypted and better authenticated session





High-Level SSH Protocol

- Client ssh’s to remote server
  - `$ ssh username@somehost`

Host Validation

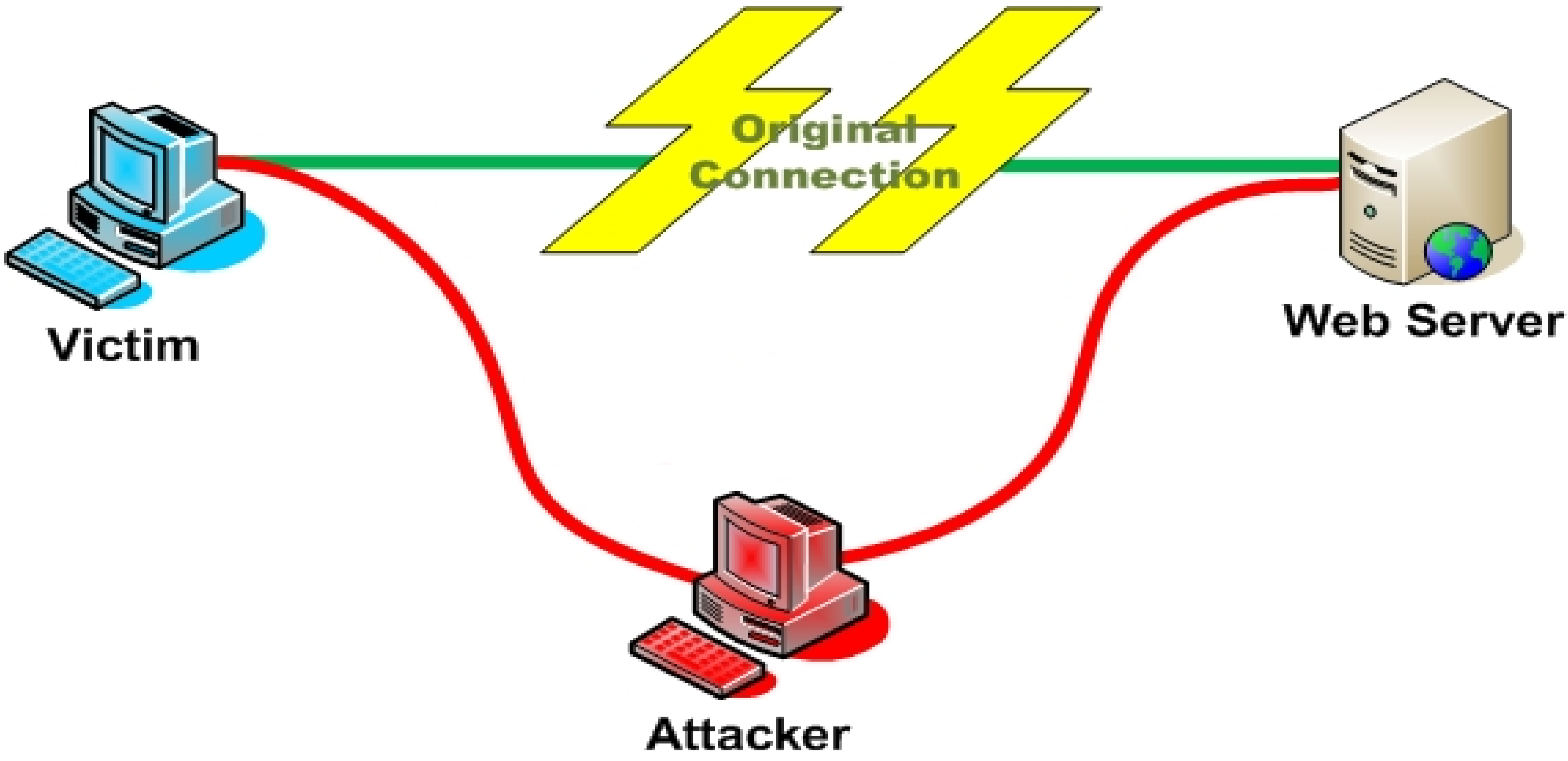
- If first time talking to server -> host validation

```
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:



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 (passphrase-less ssh)

- 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)

Client Steps

- **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.

Client Steps – Make logins convenient

- **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**
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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