SSH - Secure Shell

Week 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

- 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

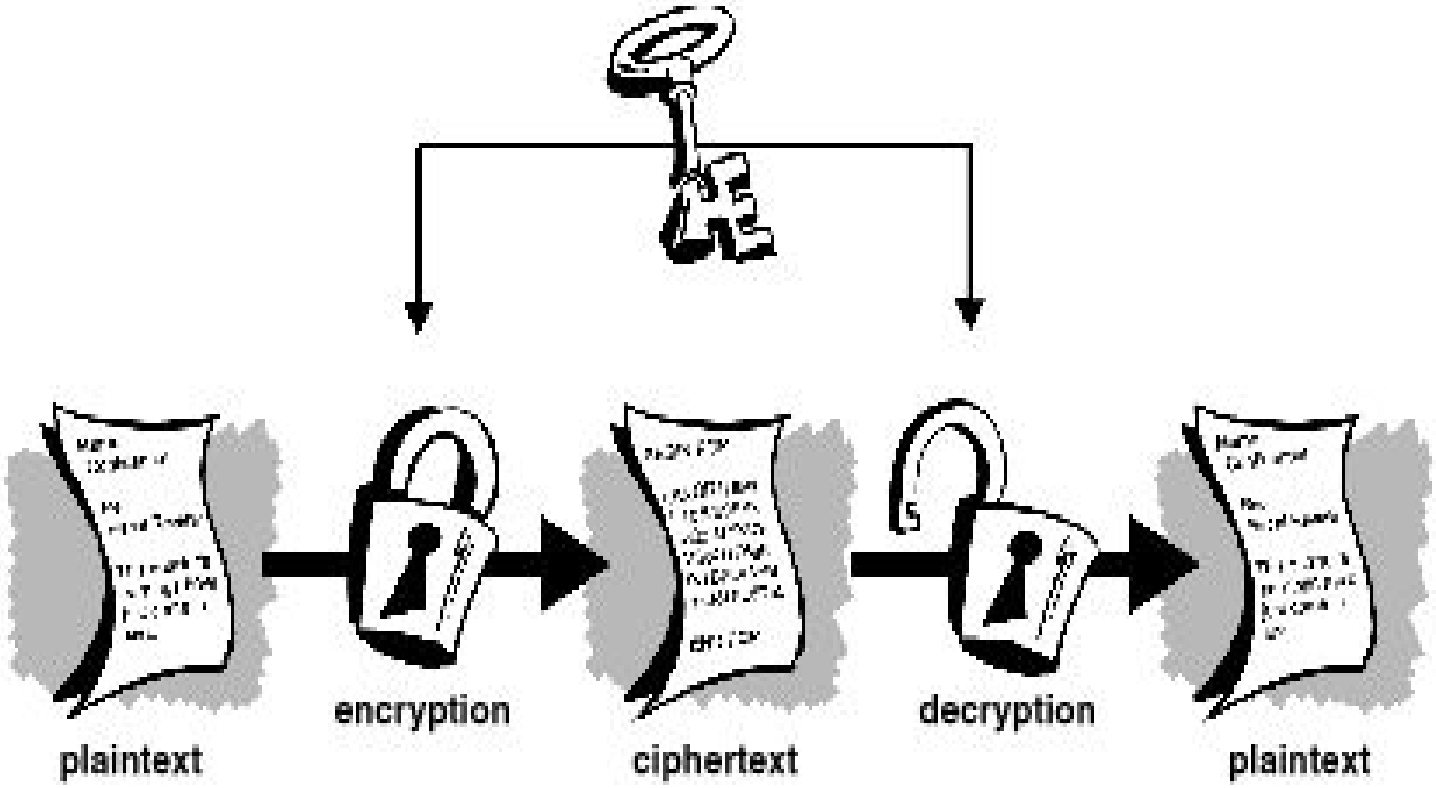


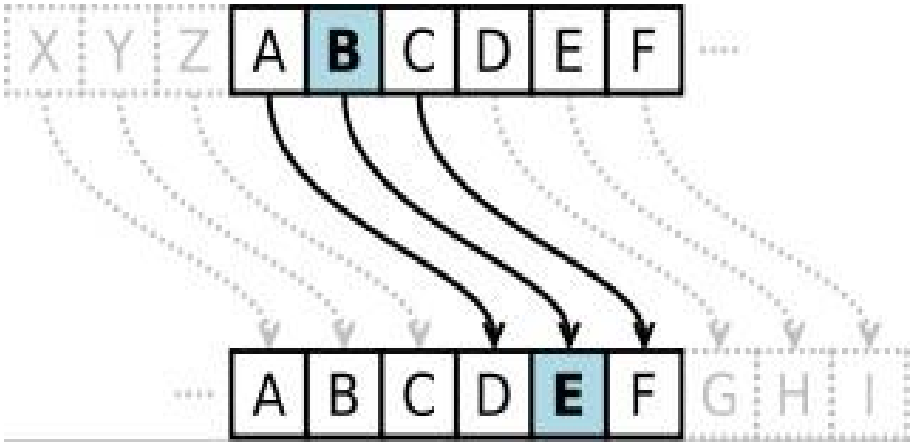
Image Source: gpgtools.org

Symmetric-key Encryption

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

Caesar’s cipher

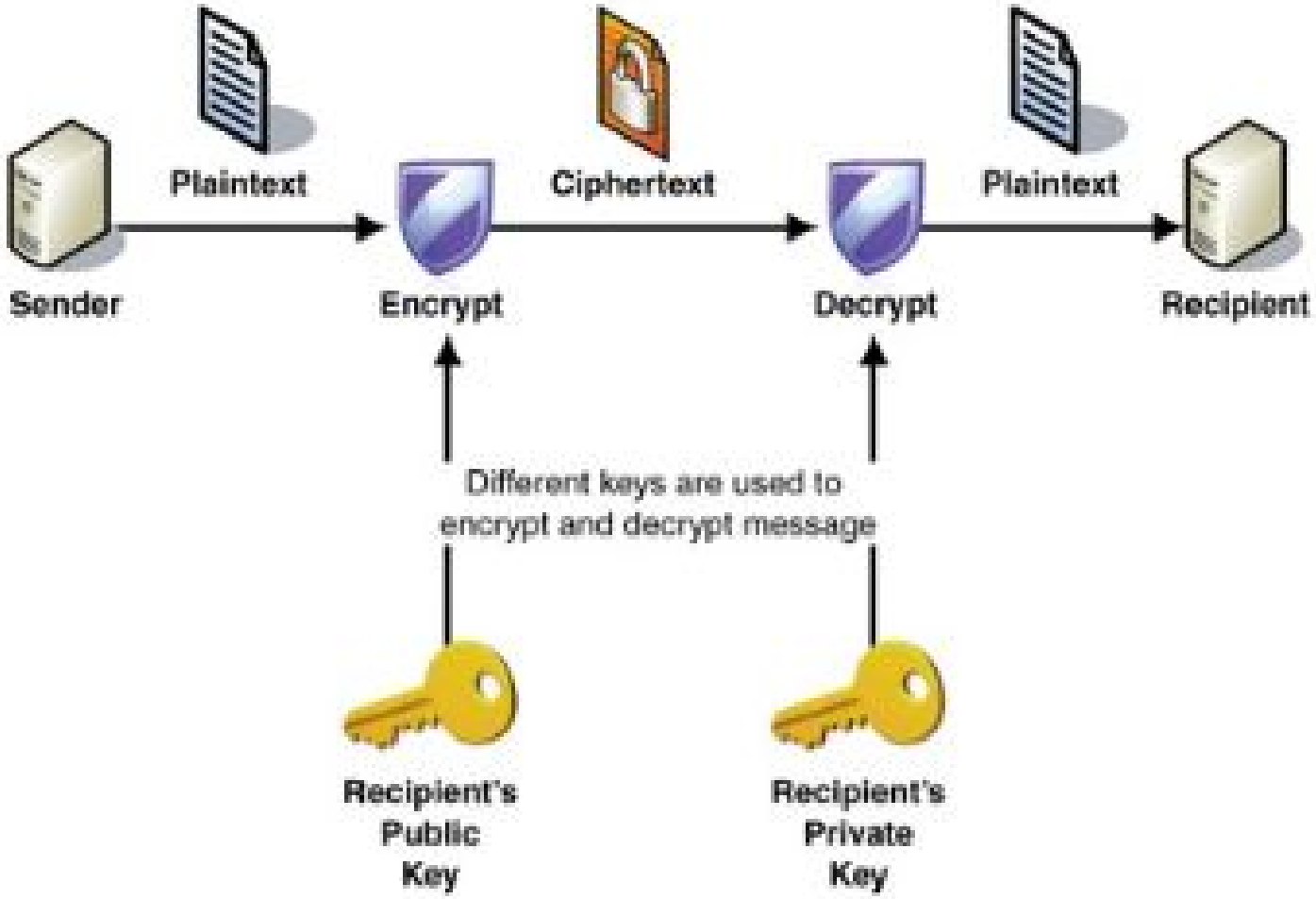
- When key is 3
  - ABCDEFGHIJKLMNOPQRSTUVWXYZ
  - DEFGHIJKLMNOPQRSTUVWXYZABC



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)



Public-Key Encryption (Asymmetric)

- Example: RSA (Rivest, Shamir & Adelman)
  - 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

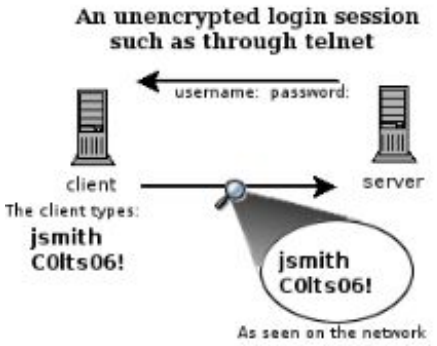
en.wikipedia.org/wiki/RSA_Factoring_Challenge

Encryption Types Comparison

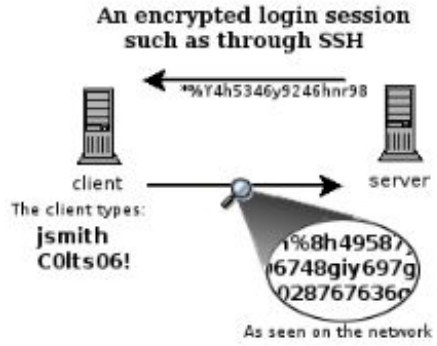
- **Symmetric Key Encryption**
  - a.k.a shared/secret key
  - Key used to encrypt is the same as key used to decrypt
- **Asymmetric Key Encryption: Public/Private**
  - 2 different (but related) keys: public and private
    - Only creator knows the relation. Private key cannot be derived from public 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)

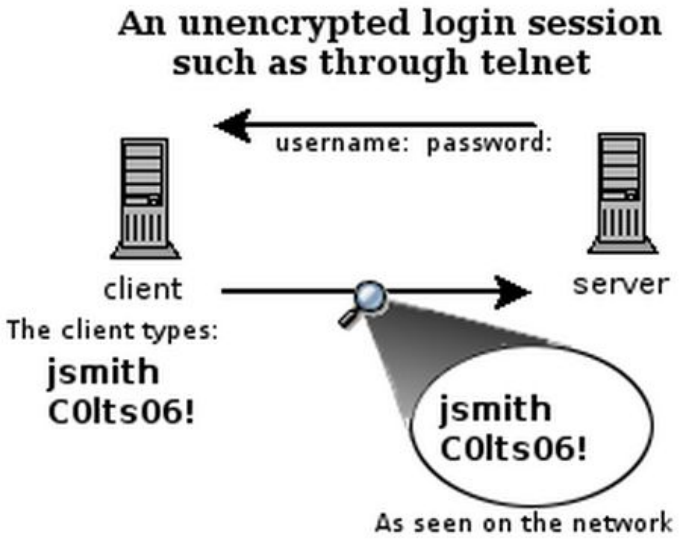


- SSH
  - run processes remotely
  - encrypted session
  - Session key (secret key) used for encryption during the session



What is SSH?

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



High-Level SSH Protocol

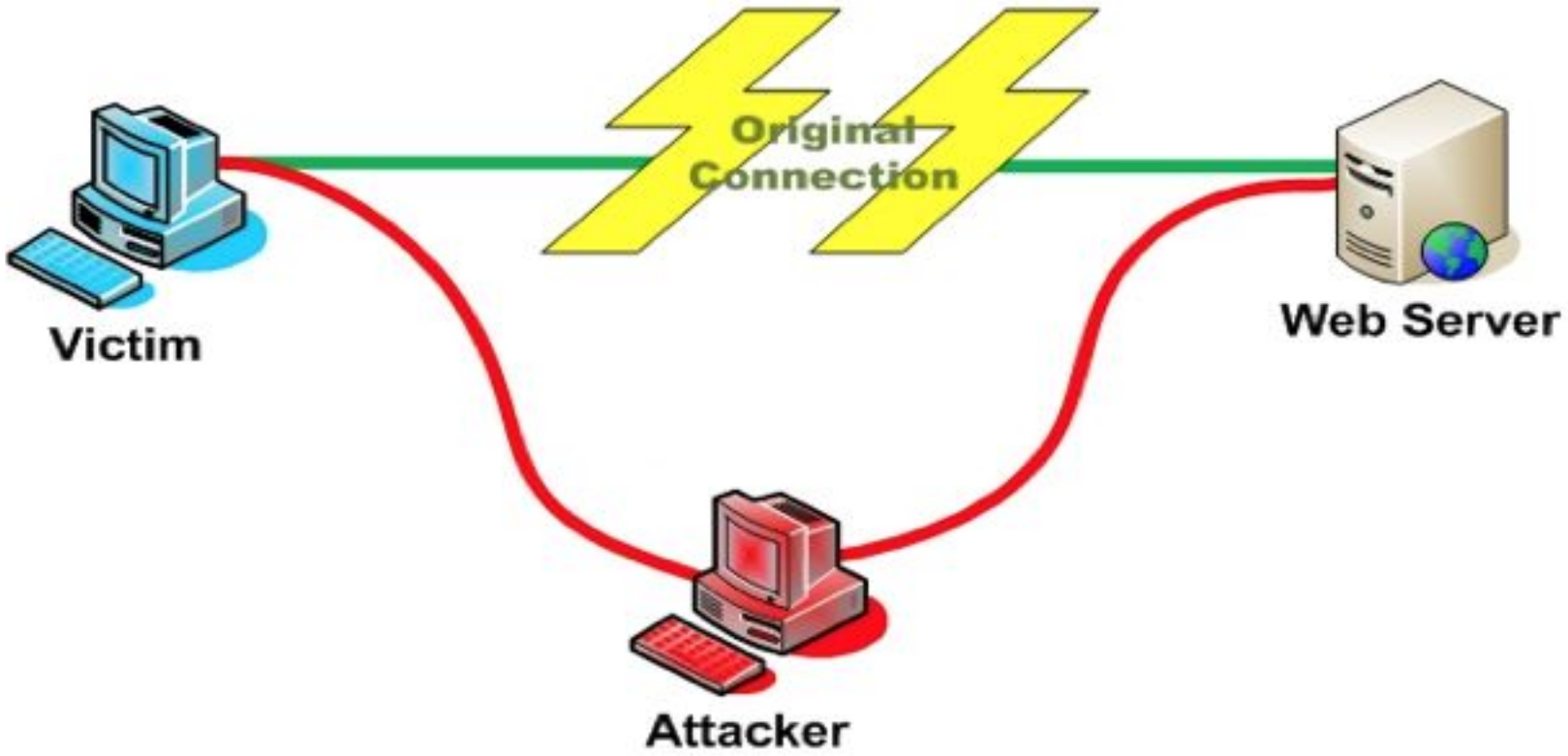
- Client ssh's to remote server
  - `$ ssh username@somehost`
  - If first time talking to server -> host validation

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

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!)

Secure Shell (SSH) - Client Authentication

- **Password** login
  - `ssh username@ugrad.seas.ucla.edu`
- **Passwordless** login with keys
  - Use private/public keys for authentication (server and client authentication)
  - ssh-keygen
    - Passphrase (longer version of a password/more secure)
    - Passphrase for protecting the private key
    - Passphrase needed whenever the keys are accessed
  - ssh-copy-id username@ugrad.seas.ucla.edu
    - Copies the public key to the server (~/.ssh/authorized_keys)
  - Login without password
    - ssh username@ugrad.seas.ucla.edu
    - Run scripts/commands on the remote machine
      - ssh username@ugrad.seas.ucla.edu ls
    - But you need to provide a passphrase to use a private key

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

Secure Shell (SSH) - Client Authentication

- **Passphrase-less** authentication
  - `ssh-agent` → authentication agent
  - Manages private key identities for SSH
  - To avoid entering the passphrase whenever the key is used
  - `ssh-add`
    - Registers the private key with the agent
    - Passphrase asked only once
    - `ssh` will ask the `ssh-agent` whenever the private keys are needed

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

Secure Shell (SSH)

- **Session Encryption**
  - Symmetric encryption
  - Exchange secret key (Example - Diffie-Hellman)
- **Host/Client Validation**
  - Public-key Encryption
  - Challenge-Response
    - Host sends a “challenge” that has to be answered by the client
    - Similarly, client sends a “challenge” that has to be answered by the host

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)

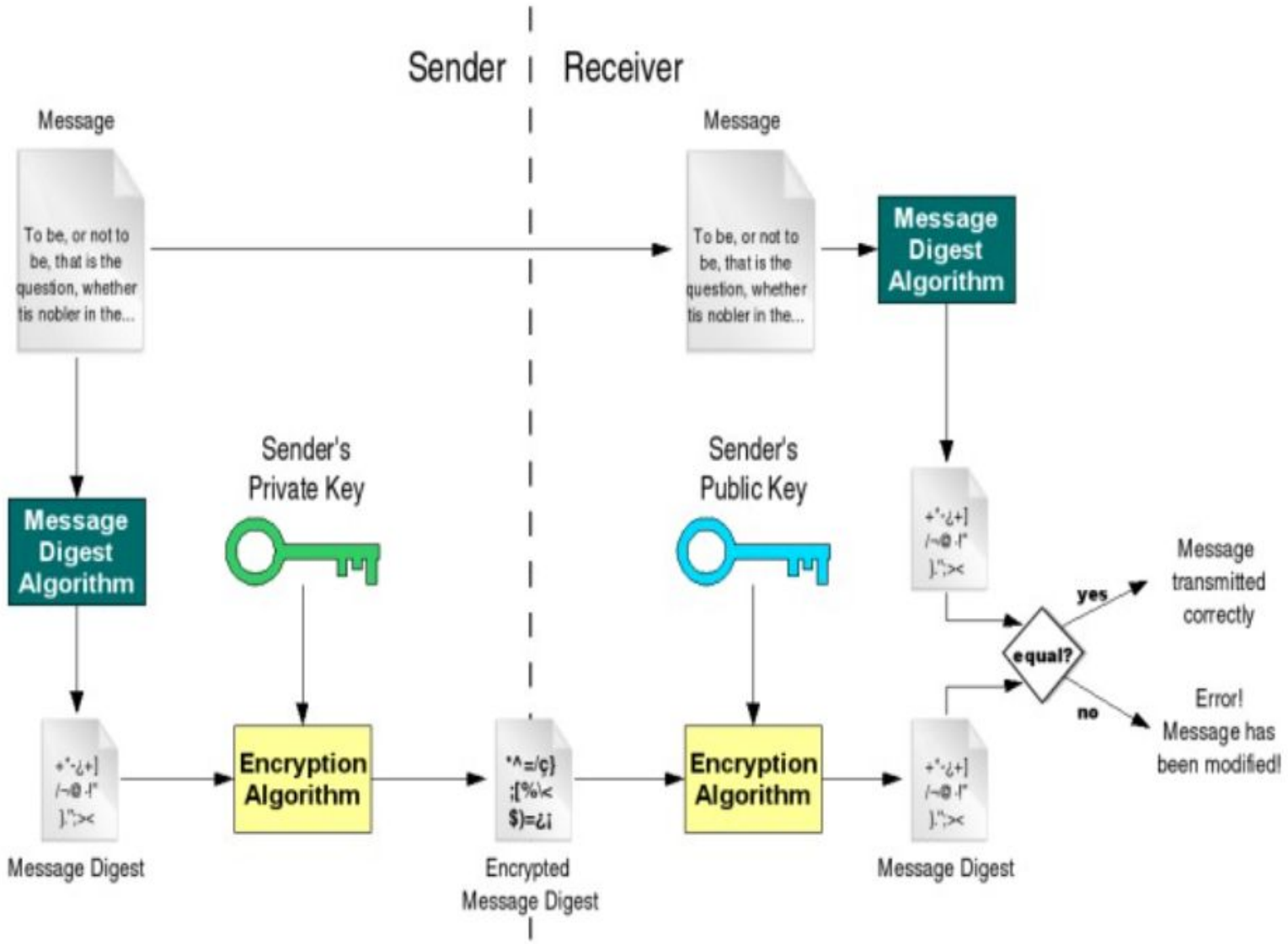
- Based on secure shell (ssh)
- Used for transferring files between hosts in a secure way (encrypted)
- Usage similar to cp
  - `scp [source] [destination]`
- Transferring to remote host
  - `scp /home/username/doc.txt username@ugrad.seas.ucla.edu:/home/user/docs`
  - Transferring from remote host
 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

Digital signature

- Protect **integrity** of the documents
  - Receiver received the document that the sender intended
- Digital signature is extra data attached to the document that can be used to check **tampering**
- Message digest
  - **Shorter** version of the document
  - Generated using **hashing** algorithms (SHA-2)
  - Even a slight change in the original document will change the message digest with **high probability**

Digital signature

Verifies document integrity, but does it prove origin? and who is the Certificate Authority?



Hints for Assignment 9

Cite Jin Wang

Lab9: Important notice

- Do not use virtual machines, please boot from USB or DVDs.
- Form groups of 2 or 3 people to finish the lab
- For the lab log, you can't just copy and paste the commands in this slides. Please explain the steps (what is the function of each command) in details to show that you understand the whole process.

Lab 9: Task

- 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

Lab Environment Setup

- Ubuntu
  - 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 update
    - *$ 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*
- Optional: disable password-based authentication
  - *$ emcas /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*
- 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

Homework 9

- Answer 2 questions in the file **`hw.txt`**
- Generate a key pair with the GNU Privacy Guard's commands
  - `$ gpg --gen-key` (choose default options)
- Export public key, in ASCII format, into **`hw-pubkey.asc`**
  - `$ gpg --armor --output hw-pubkey.asc --export 'Your Name'`
- Make a tarball of the above files + **`log.txt`** and zip it with gzip to produce `hw.tar.gz`
  - `$ tar -cf hw.tar <files>`
  - `$ gzip hw.tar` -> creates hw.tar.gz
- Use the private key you created to make a detached clear signature `hw.tar.gz.sig` for `hw.tar.gz`
  - `$ gpg --armor --output hw.tar.gz.sig --detach-sign hw.tar.gz`
- Use given commands to verify signature and file formatting
  - These can be found at the end of the assignment spec